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# PROSPECTS FOR THE DEVELOPMENT OF THE CHEMICAL INDUSTRY IN AFRICA,

(Note by the secretariat)

M65-595

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# I. INTRODUCTION

1. The chemical industry is a dynamic industry, as has been clearly demonstrated by its growth in developed countries, Western Europe and USA in particular. Since 1958 and even earlier the industry has consistently registered the highest rate of growth compared to total industrial production in the USA and in European member States of the OECD. In the latter group of countries the index of production in 1962 (1958 = 100) for chemicals was 154 as against 128 for all industry. This contrast becomes sharper when indices of 180 and over 200 for basic organic chemicals and plastics materials respectively are brought into the picture.[1/] The situation is broadly similar in Eastern Europe. For example, in Poland, the index of production rose to 192 while that for all industry rose to 145, according to the 1963 statistics.

2. The above illustrations, although by no means applicable to present African conditions, are nevertheless indicative of the important role that the chemical industry plays in the development of the economy as a whole. An assessment of the chemical industry in the region should take cognizance of its significant role; the secretariat in its studies has given due regard to this fact.

3. Because of lack of adequate information and the fact that only two sub-regions have been studied more thoroughly (East Africa and to some extent West Africa)[2/], the regional coverage is incomplete. Therefore, it has not been possible in this paper to present a balanced picture of the present and future possibilities of the chemical industry in the region. As will be noted in the following pages there are gaps in information particularly in the last sections of this paper.

4. One of the objectives of this paper is to identify those chemicals that have or seem to have possibilities for development in the region and determine possible priorities for their development. Secondly an attempt has been made to analyse the favourable and unfavourable factors affecting the development of these chemicals.

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1/ Source: The Chemical Industry, OECD, 1962-1963.

2/ Documents E/CN.14/INR/83 and E/CN.14/INR/73 and its addendum.

## II. TRADE AND IDENTIFICATION OF CHEMICALS IMPORTANT TO THE SUB-REGIONS[1/]

### Regional imports and exports

5. As shown in table 1 imports of chemicals into Africa in terms of value are substantial. For the 1956-1963 period imports increased by an average rate of 6.5 per cent from 385 to 600 million dollars. Africa's share in world imports reached its peak (8.1 per cent) in 1958 and since then it has been on the decline, 6.5 per cent in 1963. The share of chemicals in total African imports, however, was on the increase, 5.6 per cent in 1956 and 7.2 per cent in 1963.

6. With regard to exports the situation is slightly different; the average rate of growth of 4.3 per cent has been lagging behind that of imports. Export value in 1963 stood at 110 million dollars. African exports as a per cent of world exports ranged between 1.2 in 1963 and 1.5 in 1957 showing an over-all fall in Africa's share. The share of chemicals in total imports seems to be increasing, although some irregularities are evident.

7. As may be expected a big part of the trade in chemicals is with developed countries. Over 90 per cent of the 1963 imports had their origin from EEC (48 per cent), EFTA (28 per cent), North America (11 per cent) and Eastern Europe (2.7 per cent). These groups of countries are also the leading importers of chemicals from Africa with 30, 10 and 6.4 per cent going to EEC, EFTA and North America respectively.

### Imports and exports by groups of chemicals and sub-regions

8. Import and export values of chemicals for the years 1952, 1956 and 1961 are set forth in table 2. As regards 1961 imports, medicinal

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1/ The countries under each sub-region are shown in Table 4.

TABLE 1

Regional imports and exports of chemicals compared with that of the world, and total commodity regional imports and exports

(In million US dollars)

| | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | rate of growth (%) |
|---|---|---|---|---|---|---|---|---|---|
| Imports | 385 | 465 | 480 | 490 | 540 | 570 | 550 | 600 | 6.5 |
| Exports | 81 | 89 | 84 | 95 | 91 | 110 | 115 | 110 | 4.3 |
| Net imports | 304 | 376 | 396 | 395 | 449 | 460 | 435 | 490 | 7.0 |
| World imports = world exports | 5220 | 5770 | 5900 | 6620 | 7450 | 7910 | 8470 | 9330 | 8.3 |
| African share in world imports (%) | 7.4 | 8.1 | 8.1 | 7.4 | 7.2 | 7.2 | 6.5 | 6.5 | |
| African share in world exports (%) | 1.5 | 1.5 | 1.4 | 1.4 | 1.2 | 1.4 | 1.4 | 1.2 | |
| Total imports | 6640 | 7380 | 7330 | 7190 | 7830 | 7750 | 7480 | 8250 | 3.2 |
| Total exports | 5650 | 5700 | 5600 | 5820 | 6360 | 6520 | 6710 | 7490 | 4.0 |
| Share of chemicals in total imports (%) | 5.6 | 6.2 | 6.3 | 6.8 | 6.7 | 7.2 | 7.1 | 7.2 | |
| Share of chemicals in total exports (%) | 1.1 | 1.6 | 1.5 | 1.6 | 1.4 | 1.7 | 1.9 | 1.5 | |

Source: Data derived from Monthly Bulletin of Statistics, UN, February 1960, March 1962, 1963 and 1965 issues.

and pharmaceutical products ranked highest accounting for 26.4 per cent of total imports of chemicals. Excluding the chemical materials and products n.e.s. group, manufactured fertilizers (12.9 per cent) took second place and were followed by soaps, cleansing and polishing preparations (9.5 per cent), pigments, paints, varnishes and related materials (7.2 per cent), explosives and pyrotechnic products (5.7 per cent) and perfumery and cosmetics, dentifrices and toilet preparations (4.8 per cent).

9. The situation with regard to exports is somewhat different. Manufactured fertilizers, by far, lead the other groups and accounted for 39.5 per cent. From the remaining groups medicinal and pharmaceutical products (19.3 per cent), essential oils, perfumes and flavour materials (17.9 per cent) and dyeing and tanning extracts and synthetic tanning materials (8.9 per cent) were the most important.

10. As will be seen from table 3, 50 per cent of the total imports of chemicals into the sub-regions went to North Africa. The remaining 50 per cent was distributed as follows: West Africa 24.0 per cent, East Africa 20.3 per cent and Central Africa 5.7 per cent. The same table shows the percentage share within each group according to sub-regions. In all groups, excepting explosives and pyrotechnic products and pigments, paints, varnishes and related materials, North Africa occupied first place. With regard to the former group, East Africa leads with 39.5 per cent. West Africa with 39.0 per cent took first place in the latter group.

11. The export pattern was somewhat similar to that of imports, North Africa accounting for 77.5 per cent and Central Africa 0.7 per cent. The difference here was that East Africa with 16.7 per cent ranked second and West Africa with 5.1 per cent, third.

12. From among the groups exported from Africa, some four of them are of importance. Manufactured fertilizers came first. It consisted of phosphate fertilizers and was almost entirely from North Africa. Medicinal and pharmaceutical products came next. This group was again a North African export item. In the essential oils, perfumes and flavour

TABLE 2

Import and export of chemicals into and from the four sub-regions

(in 1,000 US Dollars)

| GROUP | COMMODITY DESCRIPTION (SITC revised) | IMPORTS | | | EXPORTS | | | 1961 percentage share of commodity | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1952 | 1956 | 1961 | 1952 | 1956 | 1961 | Import | Export |
| 512 | Organic chemicals | 2,649 | 7,577 | 17,350 | 496 | 888 | 458 | 4.24 | 1.90 |
| 513 | Inorganic chemicals | | | 17,819 | | | 297 | 4.35 | 1.23 |
| 514 | Other inorganic chemicals | 26,287 | 31,563 | 13,469 | 4,797 | 4,590 | 148 | 3.30 | 0.61 |
| 515 | Radioactive and associated materials | | | 33 | | | 4 | | - |
| 521 | Mineral tar and crude chemicals from coal, petroleum and natural gas | 925 | 510 | 1,348 | - | - | - | 0.33 | - |
| 531 | Synthetic organic dyestuffs, natural indigo and colour lakes | 3,160 | 4,217 | 6,681 | - | 2 | 5 | 1.63 | - |
| 532 | Dyeing and tanning extracts and synthetic tanning materials | 5,467 | 1,260 | 2,968 | 4,433 | 5,498 | 2,143 | 0.30 | 8.85 |
| 533 | Pigments, paints, varnishes and related materials | 15,037 | 31,346 | 29,383 | 95 | 425 | 155 | 7.15 | 0.64 |
| 541 | Medicinal and pharmaceutical products | 47,743 | 80,022 | 108,171 | 877 | 2,216 | 4,663 | 26.40 | 19.30 |
| 551 | Essential oils, perfumes and flavour materials | 10,024 | 11,103 | 6,259 | 1,271 | 3,023 | 4,316 | 1.51 | 17.90 |
| 553 | Perfumery and cosmetics, dentifrices and toilet preparations (except soaps) | 23,946 | 44,973 | 19,610 | 186 | 1,200 | 327 | 4.78 | 1.35 |
| 554 | Soaps, cleansing and polishing preparations | | | 38,941 | | | 124 | 9.50 | 0.53 |
| 561 | Fertilizers, manufactured | 53,507 | 41,905 | 52,589 | 1,524 | 4,463 | 9,509 | 12.90 | 39.50 |
| 571 | Explosives and pyrotechnic products | 10,912 | 19,233 | 23,229 | 25 | 165 | 36 | 5.65 | 0.14 |
| 581 | Plastic materials, regenerated cellulose and artificial resins | 23,408 | 47,673 | 13,970 | 206 | 553 | 10 | 3.40 | 0.04 |
| 599 | Chemical materials and products n.e.s. | | | 58,120 | | | 1,927 | 14.20 | 8.00 |
| | TOTAL | 223,065 | 321,382 | 409,940 | 13,910 | 23,023 | 24,122 | 100.00 | 100.00 |

SOURCES : EEC, Associated Overseas Areas Trade Statistics
ECA, Foreign Trade Statistics of Africa, "Series B"
National Publications

TABLE 3

1961 Import and Export of Chemicals according to Sub-regions

(V = Value in 1,000 US Dollars)

| GROUP | Commodity Description (SITC revised) | | IMPORTS | | | | | EXPORTS | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | North Africa | West Africa | Central Africa a/ | East Africa f/ | Total | North Africa | West Africa | Central Africa | East Africa | Total |
| 512 | Organic chemicals | V | 9,468 | 1,886 | 276 | 5,720 | 17,350 | 363 | 85 | 6 | 4 | 458 |
| | | % | 54.5 | 10.8 | 1.7 | 33.0 | 100 | 79.0 | 18.7 | 1.4 | 0.9 | 100 |
| 513 | Inorganic chemicals | V | 7,718 | 1,293 | 7,664 | 1,144 g/ | 17,819 | 220 | 46 | 27 | 4 | 297 |
| | | % | 43.3 | 7.3 | 43.0 | 6.4 | 100 | 74.0 | 15.5 | 9.1 | 1.4 | 100 |
| 514 | Other inorganic chemicals | V | 8,653 | 1,771 d/ | 1,575 | 1,470 g/ | 13,469 | 146 | 2 | - | - | 148 |
| | | % | 64.0 | 13.6 | 11.6 | 10.8 | | | | | | |
| 515 | Radioactive and associated materials | V | 32 a/ | - | - | 1 h/ | 33 | - | 4 | - | - | 4 |
| | | % | 97.0 | - | - | 3.0 | 100 | - | 100 | - | - | 100 |
| 521 | Mineral tar and crude chemicals from Coal, petroleum and natural gas | V | 796 | 292 | 11 | 249 | 1,348 | - | - | - | - | - |
| | | % | 59.0 | 21.6 | 1.0 | 18.4 | 100 | - | - | - | - | - |
| 531 | Synthetic organic dyestuffs, natural indigo and colour lakes | V | 4,003 | 2,072 | 28 | 578 | 6,681 | 3 | 2 | - | - | 5 |
| | | % | 60.0 | 31.0 | 0.4 | 8.8 | 100 | 60.0 | 40.0 | - | - | 100 |
| 532 | Dyeing and tanning extracts and synthetic tanning materials | V | 1,925 | 139 | 11 | 893 | 2,968 | - | - | - | 2,143 | 2,143 |
| | | % | 64.8 | 4.8 | 0.4 | 30.0 | 100 | - | - | - | 100 | 100 |
| 533 | Pigments, paints, varnishes and related materials | V | 10,835 | 11,436 | 1,317 | 5,795 | 29,383 | 138 | 9 | 3 | 5 | 155 |
| | | % | 36.7 | 39.0 | 4.6 | 19.7 | 100 | 89.0 | 5.8 | 2.0 | 3.2 | 100 |
| 541 | Medicinal and pharmaceutical products | V | 53,409 | 32,488 | 4,686 | 17,588 | 108,171 | 4,617 | 14 | 16 | 16 | 4,663 |
| | | % | 49.4 | 30.0 | 4.4 | 16.2 | 100 | 99.1 | 0.3 | 0.3 | 0.3 | 100 |
| 551 | Essential oils, perfumes and flavour materials | V | 3,083 | 2,264 | 99 | 813 | 6,259 | 2,645 | 74 | 1 | 1,596 | 4,316 |
| | | % | 49.2 | 36.1 | 1.6 | 13.1 | 100 | 61.2 | 1.7 | - | 37.1 | 100 |
| 553 | Perfumery and cosmetics, dentifrices and toilet preparations (except soaps) | V | 7,217 | 7,048 | 1,458 | 3,887 | 19,610 | 265 | 24 | 38 | - | 327 |
| | | % | 36.6 | 35.8 | 7.9 | 19.7 | 100 | 81.0 | 7.4 | 11.6 | - | 100 |
| 554 | Soaps, cleansing and polishing preparations | V | 15,157 b/ | 14,151 | 1,799 | 7,834 | 38,941 | 76 | 39 | 8 | 1 | 124 |
| | | % | 39.0 | 36.4 | 4.6 | 20.0 | 100 | 61.3 | 31.4 | 6.5 | 0.8 | 100 |
| 561 | Fertilizers, manufactured | V | 35,675 | 3,176 | 891 | 12,847 | 52,589 | 8,976 | 353 | 2 | 178 | 9,509 |
| | | % | 68.0 | 6.0 | 1.7 | 24.3 | 100 | 94.4 | 3.8 | - | 1.8 | 100 |
| 571 | Explosives and pyrotechnic products | V | 5,556 | 7,294 | 1,224 | 9,155 | 23,229 | 16 | 3 | 13 | 4 | 36 |
| | | % | 24.1 | 31.0 | 5.4 | 39.5 | 100 | 44.3 | 8.3 | 36.4 | 11.1 | 100 |
| 581 | Plastic materials, regenerated cellulose and artificial resins | V | 7,382 c/ | 2,562 | 493 | 3,533 | 13,970 | 4 | 5 | - | 1 | 10 |
| | | % | 52.8 | 18.3 | 3.5 | 25.4 | 100 | 40.0 | 50.0 | - | 10.0 | 100 |
| 599 | Chemical materials and products n.e.s. | V | 33,255 | 10,768 | 1,849 | 12,248 | 58,120 | 1,263 | 532 | 40 | 92 | 1,927 |
| | | % | 57.2 | 18.6 | 3.2 | 21.0 | 100 | 65.2 | 27.4 | 2.7 | 4.7 | 100 |
| | Total | V | 204,165 | 98,640 | 23,381 | 83,755 | 409,940 | 18,732 | 1,192 | 154 | 4,044 | 24,122 |
| | | % | 50.0 | 24.0 | 5.7 | 20.3 | 100 | 77.5 | 5.1 | 0.7 | 16.7 | 100 |

Source: Data derived from table 2.

a/ Algeria and Tunisia only, b/ Excluding Morocco, c/ Excluding Morocco, Algeria and UAR, d/ Excluding Nigeria, e/ Excluding Congo Leo., f/ Excluding Ethiopia, g/ Excluding Rhodesia, Malawi and Zambia, h/ Madagascar only.

materials group, the first and last items made up for the bulk; North Africa exporting the largest amount 61.2 per cent and East Africa exporting 37.1 per cent. The last major group is dyeing and tanning extracts and synthetic tanning materials. The value figures in the table refer mainly to wattle bark and extract entirely originating from East Africa.

13. There are two major items of export from East Africa not specifically mentioned in the table. These are soda ash from Kenya and pyrethrum flowers and extracts from East Africa.

Selection of chemicals important to the region

14. One of the objectives of this section is to determine what chemicals or groups of chemicals are of importance to the region from the point of view of imports and exports.[1/] The obvious conclusion that may be drawn from the preceding paragraphs is that medicinal and pharmaceutical products are the most important imports and manufactured fertilizers the most important exports. Therefore the logical conclusion is that these groups should be given the highest priority for development in the chemical industry in the region. As regards the former group successful development will depend mainly on:-

(a) Basic chemical industries (prerequisites for the manufacture of many basic medicinal and pharmaceutical products). These are as yet non-existent in most countries.

(b) Well organized laboratories and research institutes, which are very costly and have not yet been established in most countries of the region.

(c) Skilled and experienced high level personnel essential for quality control.

(d) Ability to cope with the fast changing nature of the products put on the market.

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1/ As in most African countries imports can be equated for consumption, the question of consumption is, to some extent, implied in the objective.

15. Briefly the pre-conditions for the creation of this sector of the chemical industry are still in the very early stages of development. This sector has, consequently, not been given the priority it seems to deserve in the first phase of the secretariat's studies on chemicals.[1/]

16. The next group as already noted above is manufactured fertilizers. In terms of tonnage this is the leading group. As was noted earlier, this group occupies first place among the groups exported from Africa. Therefore from the point of view of both imports and exports fertilizers should be accorded high priority.

17. In addition to the current volume of trade there are other reasons why fertilizers deserve special attention in the development programme. These include, significant rise in future demand, and the impact of the fertilizer industry on the development of the whole economy. In addition fertilizers are the largest consumers of basic chemicals, such as, sulphuric acid and ammonia, hence developing the fertilizer industry would stimulate growth of some of the basic chemical industries.[2/] As basic chemicals are the back bones of the chemical and related industries their development in connexion with the fertilizer industry is desirable. The importance of basic chemicals in metallurgy, textiles and other branches of industry cannot be over-emphasized. It is nowadays hardly possible to find an industry which does not make use of basic chemicals directly or indirectly. The fertilizer-basic chemical relationship is, therefore, an advantage in introducing and developing the chemical industry, in most African countries, and as such, fertilizers and basic chemicals have been given the highest priority in the work programme of the secretariat in the field of chemicals.

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1/ This does not refer to establishments which prepare and pack medicinal and pharmaceutical products imported in finished or semi-finished forms. A number of them are in operation and more are coming up.

2/ This has been the case in Africa. With the exception of sulphuric acid plants in Zambia and Congo Leo., the sulphuric acid plants in Africa have been developed as units of fertilizer plants. The same goes for ammonia.

18. With regard to the remaining groups it was considered advisable to deal with individual chemicals which are prerequisites for the further development of industry in general or whose demand is peculiar to a country, sub-region or region. Sodium xanthate, a floatation agent for non-ferrous metal ores was, for example, peculiar to Zambia. Basic chemicals (not related to the manufacture of fertilizers), explosives, calcium carbide, aluminium sulphate, pesticides (DDT and BHC), synthetic resins, viscose rayon and others which appear to offer scope for development were considered as sub-regional possibilities. Among the groups which offer scope for development on a regional level is medicinal and pharmaceutical products. Most of the chemicals in this group are low-volume high-value commodities. In other words transport costs which are a major item of the cost of goods in Africa is very small (in relation to value) for this group. This advantage coupled with the expected improvement of the unfavourable pre-conditions existing now would, it is hoped, offer scope for the development of this group on a regional scale.

19. In the following sections an attempt has been made to deal with individual chemicals or groups in greater detail.

## III. FACTORS FOR AND AGAINST THE DEVELOPMENT OF THE CHEMICAL INDUSTRY IN THE REGION

20. As may be expected there are a number of factors influencing the development of the chemical industry in the region in one way or another. Because of the limited scope of this study, only the most important factors are considered.

Unfavourable conditions

21. High investment cost - A number of factors contributing to the high cost of investment are discussed below:-

22. Limited Market - From among the factors which may hinder or retard the establishment of chemical industries, the limited market in most African countries appears to be the most important. Present consumption of and future demand for most chemicals in individual countries do not justify their production on a country basis. This is true with many chemicals, even when considered on a sub-regional scale. As a result of this limited size of the market, the advantages to be derived from the economies of scale of large integrated chemical complexes can not be attained.[1/] To begin with the capacity for the basic product will, in most cases, be small. Next the intermediates or end-products that can be derived from the basic product will be limited both in number and volume. In other words the numbers and sizes of the facilities that can be incorporated with the complex or that can draw raw material from the basic plant to form a complex is limited in scope. Under such conditions, that is in the absence of adequate inter-dependence of products and processes, the investment per unit of product would be very high.

23. Site - Site is another factor which may increase investment costs per unit considerably. As is the case in most developing countries many

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1/ According to document PET/CHEM/CONF.107, The Role of the Domestic Market in the Development of Petrochemical Industries and the need for exports in Relation to Economies of Scale, fixed plant investment for an integrated nitrogenous fertilizer complex has, for example, been estimated to be 20 to 30 per cent less than for a plant with the same output but made up of separate individual units.

ancillary facilities are not readily available in the vicinity of the site. Provisions for one or more of the following facilities may have to be made:

(a) Generation of electric power and/or steam
(b) Water purification and/or sewage and waste disposal
(c) Workshop for maintenance and repair
(d) Laboratory, etc.

24. Additional investment that may be required over and above that of the 'battery-limit' investment cost will vary according to the ancillary processes that would be needed. It can be minimized by planning off-site or ancillary facilities to serve other industries as well.

25. High cost of equipment and installation - Transportation of machinery, equipment, building materials, construction tools and equipment, spare parts and supplies from the place of origin to the site involves an expenditure which is not incurred in developed countries. Additional cost is also incurred in installation. This is because of lack of skilled labour and specialists who have to be obtained from abroad at a high cost.

26. The sum of the extra investment due to site and equipment and installation may result in making the plant or complex more expensive (by as much as 100 per cent) than that in a developed country.

27. High cost of production - All the disadvantages considered above are reflected in the form of capital charges which assume a role out of proportion to their normal share in the cost of production. The necessity for importing and stocking spare parts, supplies and possibly some raw materials for a longer period, and the longer period required to get the plant or complex started and reach production are other factors contributing to the high cost of production, especially during the first few years of operation.

28. Lack of trained labour - The problem of man-power is another unfavourable factor. Unlike in many other industries the personnel requirement for the chemical process sector is small but of high calibre involving a high proportion of chemical and other engineers, chemists, managerial

and clerical staff. There is, obviously, a shortage of trained people competent to operate even the most simple chemical plants. The chemical plants in existence in many countries depend on highly paid foreign specialists and skilled staff. As a result, although, representing a small fraction of production costs in most chemical processes, the labour cost component in the cost of production is higher than that in a developed country.

29. As there are not so many chemical industries in Africa at present, the problem of personnel is probably not acute in most countries. This is, however, bound to be the case shortly. Recently, a certain country in Africa, for instance, found it difficult to obtain labour with chemical engineering or chemistry background for a plant that it is putting up. It had to resort to training workers with background in other fields of engineering. This, evidently, is a waste that African countries cannot afford for those engineers could be usefully employed in their own fields.

30. Training personnel for the chemical industry is a long process. Because of the complex and unlimited scope of the chemical industry, the graduate chemical engineer is in reality not ready to assume a responsible position in a chemical plant just after graduation. He has a lot to learn in the plant itself, that is, in-plant training is essential to a chemical engineer as it is to the other workers. This training period is not a matter of months but of years.

31. From the preceding paragraphs it is clear that preparing chemical industry personnel is urgent and it should be done without further delay. In the long run this would mean a lot of saving for the chemical industries that will in future be established throughout the region.

32. <u>High cost of distribution</u> - In Africa cost of distribution assumes an unproportionally big part of the sales' value of goods. This especially, is the case with the high-volume low-value products, such as, fertilizers. Transport cost of fertilizers from Apapa (Lagos) to Northern Nigeria, for example, amounts to as much as 100 per cent of the cif price at Apapa. Reducing transport cost will evidently play a major role as an incentive

to the development of the chemical industry, especially those producing bulky commodities.

33. Transport facilities, which were originally developed mainly for the purpose of facilitating the movement of goods from the hinterland to the ports, are being expanded and improved in many of the countries. The rate of this process may not, however, be high enough to cope fully and efficiently with the future transport demand. In view of the crucial nature of the present and future transport situation, that is, the constraints imposed on the potential growth not only of the chemical sector but also of the economy as a whole, it is of utmost importance to improve and develop those modes of transport systems best fitted for the different areas.

34. Inadequacy of applied research organizations - Laboratories capable of evaluating raw materials, fuels and supplies as well as intermediate and final products are very essential to the development of the chemical industry. Because of their total absence in most countries and with a few exceptions their limited services in others, a number of African countries resort to laboratories outside the region. This is expensive, especially when dealing with bulky samples, and this was one of the reasons why evaluation of natural resources has been slow in some countries.

35. In addition to evaluating materials, such research organizations together with technological institutes are badly needed to help

(a) improve the efficiency of existing industries and the qualities of their products

(b) adopt existing technology to African conditions

(c) develop techniques for processing local materials hitherto not developed

(d) train industry personnel

It would, therefore, be in the interests of all countries to establish one or more scientific research centres in each of the sub-regions.

Favourable conditions

36. This section has so far dealt with factors which hinder the development of the chemical industry in Africa. Factors which favour the development of the industry will now be examined.

37. Raw materials and fuels - In general, Africa is endowed with abundant raw materials and fuels necessary for the development of the chemical industry. These together with the huge electric power potential are big assets for the chemical sector simply because these account for 60 to 80 per cent of the cost of production of many chemical products. It is because of this that a fairly detailed description of these resources has been included in the following paragraphs.

38. As regards both raw materials and fuels, although not evenly distributed, most of those needed for the manufacture of chemicals are available in the region.

39. Coal and hydrocarbons - These are fuels as well as raw materials. Their distribution in the region follows a certain pattern. The Equator roughly divides the continent into two: the coal rich south and the petroleum and natural gas rich north.

40. Of the known coal reserves of over 77,000 million tons about 80 per cent is in South Africa, 8.5 per cent in Rhodesia, 6.5 per cent in Swaziland and most of the remaining in Mozambique, Nigeria, Tanzania, Madagascar, Morocco and Congo Leo., according to descending order of importance (table 4). In general African coal is not of high quality and is non-coking. Deposits, such as, those at Wankie (Rhodesia), and some in South Africa and the UAR are exceptions.

41. The hydrocarbon rich north is very rich. It has about 97 per cent of the 2,400 billion tons of crude oil reserve in the continent. Excluding the Nigerian reserves, the North African sub-region reserves account for 94 per cent, with Algeria, Libya and the UAR as the most important petroleum countries. Of the remaining sub-regions Central Africa has 1.0 per cent and East Africa none. The rest is mainly concentrated in one country, Angola.

42. In general, African crudes are of the light type and their sulphur content is small, if at all present.

43. With regard to natural gas the distribution pattern is about the same as that for petroleum. The North African sub-region with 82 per cent leads the others and is followed by West Africa (15.2 per cent) and East Africa (1.8 per cent).

44. Sulphur and sulphur bearing materials - Sulphur and salt are the very basic raw materials upon which the chemical industry is built. Their availability in abundant quantity at reasonable prices will greatly facilitate the development of the chemical sector.

45. In spite of the general favourable conditions, with regard to resources for the chemical industry, the supply of sulphur is a limiting factor. There are no known significant sulphur deposits in the continent. As shown in table 5 most of the sulphur produced in Africa comes from pyrites, which are also not available in sufficient quantity. Excess of demand over production is met from imported sulphur or pyrites.[1/] As years go by this gap between demand and local output will certainly widen. This coupled with the rising trend of the international price of sulphur will in all probability have a retarding effect on the development of the sulphuric acid, and consequently, of the entire chemical industry of the region.

46. In view of the serious nature of the sulphur and pyrites situation in Africa, it is of utmost importance for African countries, especially those like Ethiopia with known occurrences of sulphur, immediately to start prospecting for sulphur and sulphur bearing materials. Equally important is the exploitation and utilization of gypsum which is available in a number of countries including Somalia, Libya, Tanzania, etc.

47. Salt - Both rock and solar salt are available in the region. The extent of the rock salt reserve is not known. The open surface deposit

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1/ As there is no sufficient supply of pyrites in Rhodesia, the sulphuric acid unit which is being added is based on imported sulphur.

## Availability of Raw Materials, Fuels and Electric Power for Fertilizer Industries in Africa

| Sub-region and country | (1) Proved crude petroleum 1963 (est) reserves ($10^6$ barrels) | (2) Natural gas 1960/1961 total reserves ($10^9$ m3) | (2) Hard coal (measured and inferred reserves ($10^6$ tons) | (2) Hydro-electric power (estimated exploitable potential) ($10^6$ kWh/year) | (3) Phosphates reserves ($10^6$ tons) | (3) Potash reserves ($10^6$ tons) |
|---|---|---|---|---|---|---|
| NORTH AFRICA ... | 15,915 | 2,000.65 | 166 | 85 | | |
| Morocco ..... | 15 | 0.50 | 96 | 3 | 20,000 (74% BPL)(f) | ? (10 % $K_2O$) |
| Algeria ..... | 6,500 | 2,000.00 | 20 | 15 x | Over 800 (57% BPL) | |
| Tunisia ..... | | 0.15 | - | 1 x | 1,150 (62% BPL) | Substantial |
| Libya ..... | 8,000 | .. | - | 1 x | | Over 1.6 (65% $K_2O$) |
| U.A.R. ..... | 1,400 | .. | 50 | 15 | 179 (63 % BPL) | |
| Sudan ..... | | - | - | 50 x | | |
| EAST AFRICA .... | | 44.00 | 7,313 | 366 | | |
| Ethiopia ..... | | .. | .. | 45 x | | Over 50 (25 % $K_2O$) |
| Somalia ..... | | .. | - | 1 x | | |
| Burundi ..... | | | | | | |
| Kenya ..... | | - | .. | 50 | | |
| Uganda ..... | | .. | - | 45 x | 220 (28 % BPL) | |
| Tanzania ..... | | - | 400 | 75 x | 10 (65 % BPL) | |
| Rwanda ..... | | (3) (a)44.00 | | | | |
| Zambia ..... | | - | } | } | | |
| Malawi ..... | | - | } 6,613 | } 36 | | |
| Rhodesia ..... | | - | } | } | 16 (14 % BPL) | |
| Madagascar ..... | | - | 300 | 114 | | |
| Mauritius ..... | | | | | | |
| Reunion ..... | | | | | | |
| CENTRAL AFRICA .. | 160 | 0.40 | 90 | 723-743 | | |
| Congo (Leo) ..... | | .. | 90 | 530 x | | |
| Congo (Brazza) .. | } 160 | (3) 0.40 | - | 24 | 4.8 (52 % BPL) | 30 (25 % $K_2O$ av.) |
| Gabon ..... | } | .. | - | 48 | | |
| Cameroons ..... | | .. | .. | 80-100 x | | |
| C.A.R. ..... | | .. | - | 28 | | |
| Chad ..... | | .. | - | 13 x | | |
| WEST AFRICA .... | 555 | 375.00 | 406 | 140 | | |
| Nigeria ..... | 550 | 375.00 | 406 | 17 | | |
| Dahomey ..... | | .. | - | 3 | | |
| Togo ..... | | .. | - | 2 x | 120 (65 % BPL) | |
| Ghana ..... | | .. | - | 9 | | |
| Ivory coast .... | | - | - | 20 | | |
| Liberia ..... | | - | - | 25 x | | |
| Sierra Leone ... | | - | .. | 10 x | | |
| Guinea ..... | | - | - | 25 x | | |
| Gambia ..... | | - | - | .. | | |
| Senegal ..... | 5 | .. | - | 16 x | 197 (65 % BPL) | |
| Mauritania ..... | | - | .. | - | 1 (56 % BPL) | |
| Mali ..... | | - | .. | 13 x | | |
| Upper Volta .... | | - | - | .. | | |
| Niger ..... | | - | - | .. | | |
| OTHER COUNTRIES . | 250 | | 69,085 | 278 | | |
| Mozambique ..... | | .. | 700 | 45 x | | |
| South Africa ... | | - | 63,355 | .. | 93 (30 % BPL) | |
| S.W. Africa .... | | | | | | |
| Swaziland ..... | | - | 5,022 | | | |
| Basutoland ..... | | - | | 3 | | |
| Bechuanaland ... | | - | | | | |
| Angola ..... | 250 | .. | 8 | 230 x | 42 (up to 74% BPL) | |
| Spanish Sahara .. | .. | .. | .. | .. | 600 (48 % BPL) | |
| Total Africa ... | 16,880 | 2,422.05 | 77,060 | 1,602 | 17,000 (100% BPL) | Over 20 (100% $K_2O$) |
| Total World .... | 312,705.7 | (3)15,000.00 | | 5,000 | 46,697 (?) (b) | 48-68,000(100% $K_2O$) |
| % of world total . | 5.4 | 16.0 | | 32 | 52 (c) | 0.04 |

SOURCES : (1) - World Petroleum Report, 1964 ;
(2) - The Situation, Trends and Prospects of Electric Power Supply in Africa (E/CN.14/EP/3.Part I) ;
(3) - Various sources.

Notes : x - ECA Secretariat estimate
(a) - Reserve which is probably recoverable ; (b) - 1953 world reserve (Phosphate content unknown) ;
(c) - Based on 1953 African and World reserves ; (d) - Based on U.S. Bureau of Mines estimate ;
(f) - Now over 30,000 million tons of all grades .

in the Danakil Depression in Ethiopia is said to be huge and awaits exploitation on a bigger scale. Other rock salt deposits in Africa are known. They are probably of lesser importance.

48. Brine is a source of salt which is probably the least exploited in Africa. The Sua Pan brine of Makaribari Pan in Bechuanaland has recently been investigated by the Rhodesian Government. It has been reported that the results of the investigation have shown that this brine can be economically exploited to yield common salt and other salts. As this is the only known source of salt in this part of Africa (excluding coastal countries) its importance to land-locked neighbouring countries cannot be overlooked.

49. At present the share of both rock and brine salt in the total output is small. By far the biggest part of the salt produced is solar salt. Data for the total production of salt are given in Table 5. According to descending order of importance, the sub-regions producing salt are North, East, West and Central Africa with the UAR, Tunisia, Ethiopia and Algeria as the major producers.

50. Conditions for solar salt production vary from coast to coast. Because of unfavourable climatic conditions certain coastal areas in West Africa are, for example, not suitable for economic solar salt production. In contrast, in terms of climate and a high salt content of the Red Sea, the coastal area along the Red Sea is one of the most if not the most suitable. Climatic conditions in other areas would not be outside the range represented by the Red Sea and some West African Coastal areas.

51. From what has been said and the fact that part of the African salt output is nowadays exported, the prospect for the supply of salt for the chemical industry is bright. In fact it would be advisable for some African countries to consider possibilities for expanding their salt industry for the prupose of earning foreign exchange.

52. Limestone - This raw material is widely distributed in the region. It has so far been exploited mainly for the manufacture of cement. In

TABLE 5

Production of Salt and Sulphur

(in 1000 tons)

| | SALT | | | | | SULPHUR | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1948 | 1957 | 1959 | 1961 | 1963x | 1948 | 1957 | 1959 | 1961 | 1963x |
| NORTH AFRICA | .. | 820.2 | 718.4 | 974.8 | 822.7[a] | .. | .. | 49 | 98 | .. |
| Canary Islands | .. | 15.1 | 13.1 | 14.1 | 17.9 | C .. | 3 | 4 | 5 | 7 |
| Morocco | 40.0 | 52.0 | 33.8 | 21.2 | 37.3 | B - | 2 | 5 | 5 | 7 |
| Algeria | 73.0 | 116.7 | 127.6 | 128.4 | .. | B 14 | 8 | 13 | 22 | 9 |
| | | | | | | C .. | .. | 21 | 21 | .. |
| Tunisia | 105.0 | 150.0 | 92.0 | 247.0 | 320.0 | | | | | |
| Libya | 7.1 | 17.0 | 15.0 | 12.0 | 18.5 | | | | | |
| UAR | 126.0 | 416.0 | 383.0 | 517.0 | 392.0 | C .. | - | 6 | 45 | .. |
| Sudan | 36.8 | 53.4 | 53.9 | 53.1 | 37.0 | | | | | |
| EAST AFRICA | .. | 241.4 | 203.8 | 217.9[b] | 283.2[b] | B 5 | 8 | 15 | 22 | 24 |
| Ethiopia | .. | 177.0 | 140.0 | 151.0 | 225.0 | | | | | |
| French Somaliland | 60.7 | 2.3 | 0.4 | .. | .. | | | | | |
| Kenya | 16.8 | 23.0 | 19.6 | 22.9 | 17.0 | | | | | |
| Uganda | 3.0 | 9.7 | 8.9 | 6.6 | 3.1 | | | | | |
| Tanzania | 11.6 | 25.6 | 31.1 | 33.4 | 33.9 | | | | | |
| Mauritius | 3.4 | 3.8 | 3.8 | 4.0 | 4.2 | | | | | |
| Rhodesia | | | | | | B 5 | 8 | 15 | 22 | 24 |
| CENTRAL AFRICA | .. | 0.3 | 0.6 | 0.6 | 0.4 | | | | | |
| Congo (Leo.) | .. | 0.3 | 0.6 | 0.6 | 0.4 | | | | | |
| WEST AFRICA | .. | 80.7 | 89.8 | 67.3 | 87.0 | | | | | |
| Cape Verde Islands | 13.6 | 19.7 | 20.3 | 23.9 | 27.0 | | | | | |
| Senegal | .. | 61.0 | 69.5 | 43.4 | 60.0 | | | | | |
| Ghana | .. | 61 | 22.0 | 18.0 | .. | | | | | |
| OTHER COUNTRIES | 241.4 | 282.5 | 375.1 | 330.4[c] | 331.3[c] | B 15 | 162 | 198 | 177 | 155 |
| Mozambique | 10.1 | 18.0 | 18.6 | .. | .. | | | | | |
| South Africa | 153.0 | 146.0 | 237.0 | 208.0 | 198.0 | B 15 | 162 | 198 | 177 | 155 |
| South West Africa | 14.9 | 66.2 | 50.3 | 55.6 | 64.7 | | | | | |
| Angola | 63.4 | 52.3 | 69.2 | 66.8 | 68.6 | | | | | |
| | .. | 1425.1 | 1387.7 | .. | .. | .. | .. | 262 | 297 | .. |

Source: Statistical Yearbook, UN, 1964.

a/ Excluding Algeria, b/ Excluding Fr. Somaliland, c/ Excluding Mozambique, x Provisional,
B = Sulphur content in pyrites used, C = Mine production of sulphur other than under B.

a number of cases the quality of a limestone deposit is described as suitable for cement manufacture. In countries, such as, the Sudan, Burundi and Nigeria the occurrences of pure limestone, suitable for the chemical industry, are known. The difficulty with the high quality deposits is their inaccessibility at present. This situation will, of course, be expected to improve with the improvement of transportation facilities. On the whole chemical industries utilizing limestone may not be expected to experience difficulty in obtaining the right quality of limestone.

53. Phosphate rock - The region is rich in phosphate rock. About 50 per cent of world reserves of rock phosphate is in Africa. By far the largest part of the African reserves is in the Maghreb countries (North Africa), especially, Morocco. The other sub-regions have appreciable deposits some of which are being exploited for local or export purposes.

54. The quality of the African phosphate rock varies considerably from 74 per cent BPL in Morocco to less than 20 per cent BPL in Rhodesia. A number of the deposits which are being worked have beneficiating facilities. Senegal and Togo, for instance, enrich their phosphates to over 80 per cent BPL and Rhodesia (which started exploitation quite recently) to about 76 per cent BPL.

55. Africa produces about one third of world output with Morocco and Tunisia alone accounting for over 80 per cent. According to Phosphate Rock Statistics, 1963 net export of phosphate rock accounted for 88 per cent of the 13 million tons output in the same year. Consumption, according to the same source, was less than 12 per cent.[1/] These figures are but indicative of the future potential of the phosphate industry in Africa.

56. Potash - There is as yet no production of potash in the region. All sub-regions except West Africa, have potash deposits and all of them have projects to exploit them. The East African (Ethiopia) and Central African

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1/ Source: Phosphate Rock Statistics, the International superphosphates Manufacturers Asscciation Ltd., 1963.

(Congo Braz.) deposits have each an average content of 25 per cent $K_2O$ and those of North Africa (Morocco) 10 per cent $K_2O$. Although information on the actual sizes of some deposits is lacking, the present known deposits are estimated to contain at least 20 million tons of 100 per cent $K_2O$ (Table 4).

57. Electric power - Although the present electric power situation in Africa is, perhaps, not satisfactory, the potential for its development is tremendous. Africa possesses over 30 per cent of the world hydro-electric potential (Table 4). A very small part of this potential is being exploited at present.

58. The last few years have seen the beginning of the harnessing of this huge potential. Hydro-electric power plants, such as, the Kariba (Zambia-Rhodesia) and Koka (Ethiopia) have recently been put into operation. Some of the future giants are under construction: the Aswan High Dam in the UAR, the Volta Dam in Ghana and the Kainji Dam in Nigeria. These and others that will appear in the future (including thermal power plants based on natural gas, petroleum products and even coal) will ensure adequate and cheap power supply for the continent. In fact availability of power may be expected to play a major role in promoting chemical industries, such as, those producing ammonia, chlorine and caustic soda, calcium carbide and other electrothermal and electrolytic products. Electric power consumption in these industries represents a big item in the cost of production.

59. Trend of plant locations towards raw material locations - In addition to the advantages expected to be gained as a result of the presence of natural resources, there is another factor which may be expected to play an increasing role in favour of the development of the African chemical industry. This is the tendency of some basic chemical industries to be located near the sources of the major inputs, especially raw materials.

60. Recent technological break-throughs have made it possible for some developing countries with abundant and relatively cheap raw materials to put up large ammonia plants primarily for export. Trinidad provides an example of the success of such a venture. This example is being

followed by a number of developing countries. It is expected that Algeria and Libya will be among the first in Africa.

61. Although a concept at the moment, the idea of phosphoric acid plants near the source of phosphate rock is a possibility to be realized. It has been reported that an American group has already shown interest with regard to the establishment of a huge superphosphoric acid plant in Morocco. If this will prove successful, it will set a precedence for the other phosphate producing countries in the region.

62. The beneficial effects that may be expected from this new trend could be far-reaching. Availability of low-cost of such basic chemicals would result in generating more economic activities, among other things, by way of down-steam integration than would be possible if separate complexes were created based on a fully integrated concept.

63. A conclusion which may be drawn from the preceding paragraphs is that the obstacles to the development of the chemical industry are probably temporary. In other words the picture will not be as gloomy as might seem on the surface.

## IV. FERTILIZERS

### Fertilizer trade

64. Table 6 summarizes fertilizer production, consumption, exports and imports for Africa. Africa is a substantial importer of fertilizer, and imports are still growing. The largest quantities imported are nitrogenous. Potash fertilizers, which are entirely imported, take second place. Imports and exports of phosphate fertilizer are roughly balanced. The only exports of phosphates are from Tunisia and Rhodesia (concentrated superphosphate), and from South Africa and the United Arab Republic (single superphosphate). Nitrogen is imported by the majority of the African countries as ammonium sulphate, ammonium nitrate and urea. Potassium is imported as potassium sulphate and muriate over 45 per cent $K_2O$.

65. It should be mentioned that Africa is a large producer and exporter of rock phosphate. Morocco is today the largest exporter in the world, accounting for about 40 per cent of the total exports. At present some quantities of rock phosphate are also directly applied in Rhodesia, South Africa, Morocco, Tunisia and others. The total amount of rock phosphate used directly was about 60,000 tons, against 1.2 million tons of world consumption.

### Estimation of potential fertilizer demand

66. Table 7 summarizes present and future fertilizer consumption in Africa by sub-regions. For 1970 and 1980 the anticipated requirements are based on food demand for the increasing population and on cash crops expansion.

67. The growth of population is very rapid. It is expected that the population of Africa, from 273 million in 1960, will reach 346 million in 1970 and 449 million in 1980.[1/] The assumption used here is that the increase of population between 1960 and 1980 will be 176 million.

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1/ Source: United Nations, Provisional Report on World Population Prospects as Assessed in 1963, ST/SAO/SER.R/7 "Medium" estimate.

TABLE 6

Fertilizer Production, Consumption and Trade in the region
(1957/58 - 1962/63)

(in 1000 tons of pure nutrients)

| | 1957/58 | 1958/59 | 1959/60 | 1960/61 | 1961/62 | 1962/63 |
|---|---|---|---|---|---|---|
| **Production** | | | | | | |
| N | 46 | 51 | 59 | 77 | 145 | 184+ |
| $P_2O_5$ | 243 | 257 | 259 | 282 | 254 | 283 |
| $K_2O$ | 1 | - | - | - | - | - |
| | 290 | 308 | 318 | 359 | 399 | 467 |
| **Consumption** | | | | | | |
| N | 256 | 290 | 223 | 324 | 366 | 405 |
| $P_2O_5$ | 263 | 259 | 260 | 286 | 276 | 314 |
| $K_2O$ | 72 | 78 | 85 | 102 | 104 | 114 |
| | 591 | 627 | 568 | 712 | 746 | 833 |
| **Exports** | | | | | | |
| N | - | - | - | - | 1 | 4 |
| $P_2O_5$ | 54 | 54 | 54 | 55+ | 57 | 64+ |
| $K_2O$ | - | - | - | - | - | - |
| | 54 | 54 | 54 | 55 | 58 | 68 |
| **Imports** | | | | | | |
| N | 210 | 238 | 163 | 245 | 220 | 221 |
| $P_2O_5$ | 65 | 58 | 52 | 60 | 81 | 85 |
| $K_2O$ | 76 | 80 | 84 | 102 | 100 | 110 |
| | 351 | 376 | 299 | 407 | 401 | 416 |
| **Exports minus Imports** | | | | | | |
| N | -210 | -238 | -163 | -245 | -219 | -217+ |
| $P_2O_5$ | - 11 | - 4 | 2 | - 5+ | - 24+ | - 21+ |
| $K_2O$ | - 76 | - 80 | - 84 | -102 | -100 | -110 |
| | -297 | -322 | -245 | -352 | -343 | -348 |

Source: Fertilizers, An Annual Review of World Production, Consumption and Trade, 1962, 1963, FAO, Rome.

\+ Unofficial figure.

68. It is realized that additional population will not have enough food with the present methods of land cultivation. At present there is a rough sort of balance in Africa between the existing population and food supply. Even with this balance many people in the continent suffer from undernourishment and malnutrition, especially in respect to animal proteins. With continually growing population, the existing balance between the number of people and food supply will be upset, and some new improved methods of agricultural production will have to be introduced in order to produce more and better food. These will certainly require an important increase in the use of fertilizers. In the light of the results of experiments and demonstrations carried out for years in Africa, fertilizer seems to offer the best possibility for a substantial increase in agricultural production between now and 1980.

69. Other technical inputs in agriculture are also important, but it is probably less likely that they can be brought into action fast enough on a sufficiently massive basis to play a major role. It is true that in agriculture a wide range of different inputs should be applied in order to get the most effective results from each of those inputs. But it is also obvious that a high level of agricultural production would not be possible at all without the application of plant nutrients to the soil. The other inputs significantly increase the efficiency of the use of fertilizer: improved seeds, increased irrigation, pesticides and all other technical inputs must be utilized to the fullest possible economic extent; yet, it should be recognized that the principal means of raising agricultural productivity will have to be fertilizers.

70. The agricultural production increment for 1980 can be assumed to have to cover two different requirements:

(a) The total food demand of the 176 million additional people (449-273).

(b) Improvement in the basic nutrition of the population of 273 million people (1960); at least 20 per cent of that which is calculated per capita under (a).

71. On the assumption that one man needs about 2,400[1/] calories daily and that one kilogramme of grain (maize, wheat, rice, millet, sorghum, barley, teff, etc.) contains approximately 3,400[2/] calories, the daily requirement of one man is around 710 grams of grain, or about 260 kg. of grain annually. Adding this to the estimated losses in storage and wastage (about 20 per cent of yields), we would get about 330 kg. of grain. To simplify the accounts, it can be assumed that one ton of grain feeds three persons. To provide enough grain for 176 million people, the region then would require about 58.7 million tons of grain (176:3).

72. To present the problems in another fashion: one kilogramme of grain containing 3,400 calories will not necessarily be the only food. Other foods and even animal products on the basis of grain are represented here in their grain equivalent. Grain has been used as a symbol and the equivalent of that which is necessary to sustain a human being. It must be understood that the grain symbol is a considerably simplified and conservative one. In practice the problem is much more complicated, and the demand perhaps may be greater than our assumption. But neither the simplification nor the underestimation of food demand weakens the argument since, if the estimates presented in this paper are really conservative ones, how large must the future demand be in reality?

73. It has already been assumed that improvement in the nutrition of the existing population can be represented by 20 per cent of that which was estimated under (a). This means that one ton of grain will be sufficient for 15 persons ($3 \times \frac{100}{20}$). In other words there would be needed

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1/ Sources: Ignatieff, V., Doylle, J.J., Couston, J.W., Future Fertilizer Requirements of Developing Countries and Crop Response to Fertilizer in These Countries, The Fertilizer Society, Proceedings No. 83, 44 Russell Square, London, W.C.1, p.6.

2/ Food Composition Tables, FAO Nutritional Studies, No.11, FAO.

18.2 million tons of grain (273:15). This, when added to the 58.7 million tons already computed under (a), gives 76.9 million tons of grain required.

74. How can such an amount of grain be obtained? In the light of the results of trials and demonstrations carried out for years in Africa and on the basis of the experience of other countries, for instance the United States,[1] Japan,[2] and India,[3] it can be assumed that:

(a) 50 per cent of the grain required, or 38.45 million tons, can be obtained by increasing fertilizer applications. Another 50 per cent by improved use of other inputs.

(b) One kilogramme of fertilizer yields 10 kgs. of grain.

Assuming (a) and (b), in 1980 it would be necessary to apply 3,845,000 tons of fertilizer in Africa in order to obtain enough food for the future population.

75. Additional amounts of fertilizer will be necessary for the expansion of cash crops for export, but it is difficult to determine how large this increase should be. Assuming a combination of both expansion and intensification, cash crops alone may require double the 1960 over-all fertilizer consumption. Thus, about 1.4 million tons of plant nutrients will be required.

76. According to the estimates outlined above, the potential demand for fertilizer in 1980 will be about 5.2 million tons of pure nutrients (see Table 7), consisting of about 2,260,000 tons of N, about 1,960,000 tons of $P_2O_5$ and about 980,000 tons of $K_2O$.

77. The figures in Table 7, especially for 1980, may very well appear to be too ambitious but they should be regarded as showing the potential

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1/ How the United States improved its Agriculture, Development and Trade Analysis Division, Economic Research Service, US Department of Agriculture, Washington, 1964.

2/ Yang, W.Y., Farm Development in Japan, FAO, Rome, 1962.

3/ Williams, Moule S., and Couston, Y.W., Crop Production Levels and Fertilizer Use, FAO, Rome, 1962.

requirement. It must be understood that this potential demand for fertilizer can only be met under especially favourable conditions. For instance, country targets in East Africa plan a much lower level of fertilizer application in the future (Table 8).

78. Many of the African countries have development plans of one sort or another, but they are usually not very specific with respect to planned increases of fertilizer use. Some of the plans reflect the result of FAO Fertilizer Programmes operating since 1961 under the Freedom from Hunger Campaign. Ghana, Nigeria, Togo, Senegal and Gambia in West Africa, and Morocco in Northern Africa, are included in these programmes. The results obtained from thousands of trials and demonstrations are very promising and allow for the planning of future fertilizer consumption in order to cover food production demand.

79. When it is considered that from 1944/45 to 1964/65 world fertilizer consumption has increased from about 7 million tons to over 30 million tons, an increase of fertilizer consumption in Africa from 750,000 tons to 5.2 million tons in 19 years does not seem to be impossible. But considering the factors which make it difficult for the farmers in this region to use fertilizers, the level of 5.2 million tons of fertilizer will be very difficult to reach.

Factors limiting the use of fertilizers

80. Below are summarized some of the factors limiting the use of fertilizers.

(a) The high cost of fertilizers. Transport charges represent a large proportion of the total cost of fertilizers. Transportation cost could only be reduced by bulk handling, which cannot be justified at the present rate of usage.

(b) The low value of many crops grown in the region, such as cassava, bananas and maize. Most of the non-export crops have a very low cash value and although most of them show marked responses to fertilizer application, the resultant increases in yield may not be sufficiently large to warrant applying fertilizer.

TABLE 7

Fertilizer Consumption by Sub-regions

(in 1000 tons of pure nutrients)

| Sub-region and region | Nitrogen (N) | | | | | Phosphorus ($P_2O_5$) | | | | | Potassium ($K_2O$) | | | | | Total ($N+P_2O_5+K_2O$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 51/52 | 56/57 | 61/62 | 1970 | 1980 | 51/52 | 56/57 | 61/62 | 1970 | 1980 | 51/52 | 56/57 | 61/62 | 1970 | 1980 | 51/52 | 56/57 | 61/62 | 1970 | 1980 |
| North Africa | 120.8 | 146.9 | 245.5 | 450.0[a] | 900.0[a] | 59.5 | 63.6 | 98.7 | 300.0[a] | 600.0[a] | 20.0 | 15.4 | 28.9 | 75.0[a] | 200.0[a] | 200.3 | 225.9 | 373.1 | 825.0[a] | 1700.0[a] |
| South Africa | 15.5 | 27.7 | 57.1 | 200.0[a] | 450.0[a] | 105.2 | 143.4 | 152.0 | 350.0[a] | 650.0[a] | 8.1 | 20.4 | 34.9 | 100.0[a] | 300.0[a] | 128.8 | 191.5 | 244.0 | 650.0[a] | 1400.0[a] |
| East Africa | 13.0 | 28.9 | 46.9 | 220.0[a]<br>110.0[b] | 465.0[a]<br>215.0[b] | 6.5 | 24.3 | 31.7 | 220.0[a]<br>105.0[b] | 460.0[a]<br>185.0[b] | 5.1 | 15.7 | 25.0 | 110.0[a]<br>70.0[b] | 235.0[a]<br>110.0[b] | 24.6 | 68.9 | 103.6<br>285.0 | 550.0[a]<br>285.0[b] | 1160.0[a]<br>500.0[b] |
| West Africa | 1.7 | 2.0 | 5.2 | 47.0[c] | 250.0[a] | 0.4 | 1.0 | 7.6 | 53.0[c] | 150.0[a] | 0.2 | 1.7 | 9.4 | 43.0[c] | 150.0[a] | 2.3 | 4.7 | 22.2 | 143.0[c] | 550.0[a] |
| Central Africa | 0.2 | 2.3 | 2.3 | 40.0[a] | 200.0[a] | - | 0.7 | 0.7 | 25.0[a] | 100.0[a] | - | 2.1 | 1.9 | 25.0[a] | 100.0[a] | 0.2 | 5.1 | 4.9 | 90.0[a] | 400.0[a] |
| Not identified | - | -4.8 | 9.0 | - | - | - | -1.0 | -14.7 | - | - | - | -2.3 | 3.9 | - | - | - | -8.1 | -1.8 | - | - |
| TOTAL | 151.2 | 203.0 | 366.0 | 957.0 | 2265.0 | 171.6 | 232.0 | 276.0 | 948.0 | 1960.0 | 33.4 | 53.0 | 104.0 | 353.0 | 985.0 | 356.2 | 488.0 | 746.0 | 2258.0 | 5210.0 |

Source: An Annual Review of World Production and Consumption of Fertilizers 1953, and Fertilizers, An Annual Review of World Production, Consumption and Trade, 1962, 1963, FAO, Rome.

a/ Potential requirement based on ECA estimates of potential food demand.

b/ Country targets, close to estimates presented by ECA document E/CN.14/INR/83 in Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October - 2 November, 1965.

c/ Soil fertility and fertilizers in West Africa (E/CN.14/INR/70), ECA, Conference on Industrial Co-ordination in West Africa, Bamako, 5 - 15 October, 1964.

TABLE 8

Comparison of Various Estimates of Future Fertilizer Consumption in the East African Sub-region

(in 1000 tons of pure nutrients)

| Specification | 1965 | 1970 | 1975 | 1980 |
|---|---|---|---|---|
| Continuity of actual yearly increment | 140 | 180 | 220 | 260 |
| Country targets | 170 | 286 | 403 | 520 |
| Document E/CN.14/INR/83 estimate a/ | 118 b/ | 215 | 315 | 444 |
| Total potential demand | 244 | 550 | 855 | 1160 |

a/ N and $P_2O_5$ only

b/ 1964.

(c) The relatively low standard of crop husbandry for most African crops. Fertilizers are not a substitute for good farming; rather, they must be regarded as an integral part of good farming practice.

(d) Very low basic yielding of some crops, particularly food crops. Production of new varieties by the plant breeder could result in a gradual increase in basic yields.

(e) Lack of adequate supplies of fertilizers and an inadequate distribution system. This is perhaps the key problem in increasing fertilizer application.

(f) Lack of information on the kinds and amounts of fertilizer needed and on methods of application in specific circumstances. It is relatively easy to introduce fertilizer to the big farm units where continuous cultivation is practised, but the most important task is the introduction of fertilizers to small farmers. There are great possibilities for extension services to contribute to increasing fertilizer use in Africa.

(g) Tenure systems that still exist in most African countries. Such systems tend to discourage the economic use of fertilizers.

(h) The lack of adequate seed, and of disease and insect control measures and other practices that are necessary if fertilizers are to have their best effect.

(i) Additional labour required to apply fertilizer at a busy time of the year. Adoption of fertilizer seed drill by mixed farmers could reduce the labour requirements involved in application of fertilizers.

(j) Reluctance on the part of farmers to accept new techniques. This may be expected to be gradually overcome by education, propaganda and demonstration systems.

Measures for promoting use of fertilizers

81. All these impediments and obstacles will have to be overcome if fertilizer use is to become more common in Africa. In this connexion government action is necessarily very important. The following policies are most important and are possibly even required if modern agricultural methods are to be used to increase agricultural production.

(a) Provision for greatly expanded research and extension services to supply information to cultivators and to assist them in applying improved methods.

(b) Provision of practical field demonstrations with fertilizers, in combination with other means of extension and publicity (film shows, radio broadcasts, leaflets, articles, etc.).

(c) The development of an effective pricing and distribution system for farm products and farm supplies that they must have in order to make use of modern methods.

(d) An effective distribution system for fertilizers, possibly combined with a subsidy system which would cover transportation costs to very distant regions and make the price of fertilizer equal for every farmer.

(e) The development of a system of farm credit for cultivators which would provide adequate protection against uncontrollable risks, such as severe drought in some regions.

Rates and patterns of growth in production of fertilizers

82. Fertilizer output in the region is comparatively low (Table 9). According to 1953/54 figures it consisted of 0.34 and 2.85 per cent of the world output of N and $P_2O_5$ respectively. Corresponding percentages for 1962/63 were 1.45 and 2.57 showing an increase in N and a decrease in $P_2O_5$ in share of world output. Output of potash fertilizer was negligible.

83. During the 1953/54 - 1962/63 period output of nitrogenous fertilizers increased steadily from 19 to 184 thousand tons, at an average annual rate of growth of 29 per cent. The UAR and South Africa were the only producers, the former taking lead with 73 per cent of the 1961/62 output of the region. Ammonium nitrate accounted for 47 per cent of the nitrogenous fertilizer output in 1961/62. The UAR produced 95 per cent of this and South Africa the balance. According to descending order the other types of nitrogenous fertilizers produced in Africa were calcium nitrate (29 per cent), ammonium sulphate (14 per cent) and urea (8 per cent). The first was entirely produced in the UAR and the second and third in South Africa.

84. Excluding the year 1961/62 during which time output of phosphate fertilizer fell to 254 thousand tons, output of same fertilizer showed a steady rise from 187 to 283 thousand tons during the period in question. In terms of annual growth rate output grew by an average of 4.7 per cent. Unlike the region as a whole, output in some countries, such as South Africa, Algeria and Morocco, has been erratic. According to 1960/61 figures, South Africa with a share of 48 per cent occupied first place and was followed by Tunisia, the UAR, Rhodesia, Morocco, Algeria and Kenya.

85. Single superphosphate was by far the leading type of the phosphate fertilizers produced in the region. Output in 1960/61 accounted for over 70 per cent with about 66 per cent of this contributed by South Africa. From among the other types, concentrated (triple) superphosphate was the most important and Tunisia and Rhodesia the major if not the only producers.

TABLE 10

Numerical Extracts from the Bamako papers on Chemicals*

| Fertilizer | Location | Capacity (t/y) | Plant cost ($) | Production cost ($/ton) | CIF Prices ($/ton) |
|---|---|---|---|---|---|
| Single superphosphate | Togo | 116,000 | 1,520,000 | 23.0 | 45.5-47.3 |
| Single superphosphate | Ivory Coast | 93,000 | 1,320,000 | 26.5 | 45.5-47.3 |
| Triple superphosphate | Senegal[a] | 35,000 | 2,380,000 | 69.5 | 80.3-82.6 |
| Ammonium sulphate | Nigeria | 225,000 | 11,000,000 | 31.0 | 49.3-55.7 |
| Ammonium nitrate | | 10,000 | | 88.0 | 280-340[b] |

* This Table might be modified as a result of the Bamako Conference follow-up study which is being conducted presently.

a/ According to October 30, 1965 issue of Marchés Tropicaux et Méditerranéens, a 130,000 tons complex fertilizer plant is to go on stream in 1967 in Senegal.

b/ Explosive based on ammonium nitrate.

86. As has already been stated output of potash fertilizers has been negligible. South Africa produced an average of 600 tons per year from molasses during the 1954/55 - 1957/58 period. It appears that there has not been production since the end of this period.

87. The proportions in which the three plant nutrients were produced in the region shows a dramatic change. Output ratio changed from 1:10:0 in 1953/54 to 1:1.54:0 in 1962/63 while the corresponding ratios for the world were 1:1.19:1 and 1:0.86:0.74 respectively. Disregarding potash it seems that the output ratio in Africa was tending towards that of the rest of the world.

88. Comparison of output with consumption shows that the region is heavily dependent on import of nitrogenous and potash fertilizers (wholly in the case of the latter). Output of the former as per cent of consumption, however, increased from 12.6 per cent in 1953/54 to 45.5 per cent in 1962/63.

89. The picture concerning phosphate fertilizers output in relation to consumption is different. For the period 1953/54 - 1962/63 output of phosphate fertilizers as per cent of consumption ranged from 89 per cent in 1954/55 to 100 per cent in 1956/57 and 1959/60. This shows that the region has, more or less, been self sufficient in phosphate fertilizers.

Present and future state of the fertilizer industry

90. The preceding section concluded by showing the existence of disparity between production and consumption of potash and nitrogenous fertilizers for the 1953/54 - 1962/63 period. Because of lack of reliable inventory of fertilizer industries for the same period it is rather difficult to relate capacity utilization to consumption, a relation which is probably a better indicator of disparity.

91. The present and future state of the fertilizer industry in the sub-regions as well as in the whole of Africa is discussed in this section in the light of information compiled in Tables of this section.

92. West Africa - Based on papers[1/] presented at the Conference on Co-ordinated Industrialization in West Africa held in Bamako (5-15 October 1964) a number of fertilizer industries were recommended for the West African sub-region. They are expected to meet with the 1970 estimated demand of 51,000 and 53,000 tons N and $P_2O_5$ respectively.[2/] The following Table shows some numerical extracts from the Bamako papers on chemicals.

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1/ Basic Chemicals and Fertilizers (E/CN.14/INR/73 and its Addendum) and Soil Fertility and Fertilizer in West Africa (E/CN.14/INR/70) ECA, 1964.

2/ Estimate for N includes some 3,400 tons N for explosive purposes.

TABLE 9

Output compared with Consumption of Fertilizers in Africa

(1953/54 - 1962/63 - in tonnes of pure nutrients)

| Sub-region and region | 1953/54 | 1954/55 | 1955/56 | 1956/57 | 1957/58 | 1958/59 | 1959/60 | 1960/61 | 1961/62 | 1962/63 | compounded annual rate of growth (%) 1953/54-1960/61 | 1953/54-1962/63 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NITROGENOUS FERTILIZERS (N) | | | | | | | | | | | | |
| North Africa | 18,600 | 21,700 | 29,590 | 26,660 | 32,240 | 34,302 | 38,077 | 55,024 | 106,464 | (120.400) | 17.0 | 23 |
| UAR | 18,600 | 21,700 | 29,590 | 26,660 | 32,240 | 34,302 | 38,077 | 55,024 | 106,464 | (120,400) | | |
| Other countries | 400 | 4,620 | 7,963 | 13,338 | 13,338 | 16,230 | 21,024 | 22,346 | 38,185 | ( 59,300) | 78.0 | 145 |
| South Africa | 400 | 4,620 | 7,963 | 13,338 | 13,338 | 16,230 | 21,024 | 22,346 | 38,185 | ( 59,300) | | |
| Africa (total) | 19,000 | 26,000 | 38,000 | 40,000 | 46,000 | 51,000 | 59,000 | 77,000 | 145,000 | 184,000 | 22.0 | 29.0 |
| World (total) | 5,540,000 | 6,300,000 | 6,650,000 | 7,280,000 | 8,530,000 | 9,390,000 | 9,780,000 | 10,740,000 | 11,700,000 | 12,750,000 | 10.0 | 10.4 |
| African share in world output (%) | 0.34 | 0.41 | 0.57 | 0.55 | 0.54 | 0.54 | 0.60 | 0.72 | 1.24 | 1.45 | | |
| Consumption | 151,000 | 186,000 | 203,000 | 202,000 | 256,000 | 290,000 | 223,000 | 324,000 | 336,000 | 405,000 | 11.5 | 11.6 |
| Output as per cent of consumption | 12.6 | 14.0 | 18.8 | 19.8 | 18.0 | 17.9 | 26.5 | 23.8 | 39.6 | 45.5 | | |
| PHOSPHATE FERTILIZERS ($P_2O_5$)[1] | | | | | | | | | | | | |
| North Africa | 75,252 | 83,590 | 98,209 | 97,088 | 103,574 | 119,683 | 118,108 | (123,987) | (120,063) | (118,800) | 7.4 | 5.2 |
| Algeria | 20,223 | 19,680 | +20,000 | +20,000 | 14,317 | 13,268 | 15,397 | 14,153 | ( 8,800) | ( 7,500) | | |
| Morocco | 14,630 | 17,300 | 16,453 | 8,774 | 13,892 | 18,746 | 15,682 | 14,349 | 12,799 | 13,300) | | |
| Tunisia | 25,957 | 32,300 | 40,020 | +43,000 | 47,850 | 59,981 | 62,039 | ( 64,000) | ( 68,800) | ( 66,700) | | |
| UAR | 12,942 | 10,710 | 20,558 | 23,680 | 27,515 | 27,688 | 24,990 | 31,458 | 29,664 | ( 31,000) | | |
| East Africa | 750 | 1,800 | 589 | 817 | 600 | 12,553 | 17,756 | 19,218 | .. | .. | 59 | .. |
| Kenya | 750 | 1,800 | 589 | 817 | +600 | + 600 | 600 | 611 | .. | .. | | |
| Rhodesia | - | - | - | - | - | - | 11,953 | ( 16,756) | 18,607 | .. | | |
| Other countries | 112,000 | 104,192 | 112,964 | 138,805 | 138,805 | 124,666 | 125,438 | 136,297 | 118,579 | (142,000) | 3.0 | 2.7 |
| South Africa | 112,000 | 104,192 | 112,964 | 138,805 | 138,805 | 124,666 | 125,438 | 136,297 | 118,579 | (142,000) | | |
| Africa (total) | 187,000 | 187,000 | 211,000 | 235,000 | 243,000 | 257,000 | 261,000 | 282,000 | 254,000 | 283,000 | 4.0 | 4.7 |
| World (total) | 6,570,000 | 7,100,000 | 7,340,000 | 7,540,000 | 8,620,000 | 9,120,000 | 9,710,000 | 10,060,000 | 10,400,000 | 10,990,000 | 6.2 | 5.8 |
| African share in world output (%) | 2.85 | 2.63 | 2.87 | 3.12 | 2.82 | 2.82 | 2.70 | 2.80 | 2.44 | 2.57 | | |
| Consumption | 198,000 | 210,000 | 217,000 | 234,000 | 263,000 | 259,000 | 260,000 | 286,000 | 276,000 | 314,000 | 5.4 | 5.2 |
| Output as per cent of consumption | 94.0 | 89.0 | 97.0 | 100.0 | 93.0 | 99.0 | 100.0 | 98.0 | 92.0 | 90.0 | | |
| POTASH FERTILIZERS ($K_2O$) | | | | | | | | | | | | |
| Other countries | .. | 636 | 675 | 551 | 555 | - | - | - | - | .. | .. | .. |
| South Africa | .. | 636 | 675 | 551 | 555 | - | - | - | - | .. | .. | |
| Africa (total) | .. | 636 | 675 | 551 | 555 | - | - | - | - | .. | | |
| World (total) | 5,600,000 | 6,150,000 | 6,410,000 | 6,810,000 | 7,720,000 | 8,170,000 | 8,660,000 | 8,740,000 | 9,240,000 | 9,370,000 | 6.8 | 5.8 |
| African share in world output (%) | .. | 1,101 | 0.11 | 0.01 | 0.01 | - | - | - | - | - | | |
| Consumption | 47,000 | 63,000 | 65,000 | 62,000 | 72,000 | 78,000 | 85,000 | 102,000 | 104,000 | 114,000 | 11.7 | 11.0 |
| Output as per cent of consumption | .. | 0.1 | 0.1 | 0.09 | 0.08 | - | - | - | - | .. | | |

Sources: 1. An Annual Review of World Production, Consumption and Trade of Fertilizers, FAO, 1959; 2. Fertilizers: An Annual Review of World Production, Consumption and Trade, FAO, 1963.

Notes: +Unofficial figure - None or negligible
..Data not available ( )Figures from other sources, phosphates figures are for calendar years.

a/ Excludes rock phosphate output in which Africa with its 30 per cent share in world output is second to the USA.

93. An examination of the table reveals that it is quite possible to produce both phosphate and nitrogenous fertilizers at costs below c.i.f. prices. As there is no known exploitable potash deposit in the sub-region the manufacture of potash fertilizers was not considered in the papers.

94. Central Africa - Because of low estimated demand for fertilizers coupled with the unattractive nature of the raw material situation (excluding potash) it seems that the sub-region will have to go a long way before it could locally produce the three nutrients.[1/] The sub-region will have to look to both the West and East African sub-regions for nitrogenous and phosphate fertilizer supplies for some years to come.

95. The picture concerning the possibility for potash fertilizer production is, however, bright. The potash deposit at Holle (Congo Braz.) is to be exploited mainly for export. A potash refining plant of 600,000 tons (60 per cent $K_2O$) annual capacity is reported to be under construction. It is expected to go on stream before 1967.

96. East Africa - Unlike the preceding sub-regions East Africa has some fertilizer plants already in operation. Some relevant features of these plants and those under construction and planned are presented in Table 11.

97. The results and recommendations of the paper on chemicals for the Conference on the Harmonization of Industrial Development Programmes in East Africa held in Lusaka (26 October - 6 November, 1965)[2/] are set forth in the same table and are identified by an asterisk. The extension of the Tororo and Salisbury phosphate plants together with the new

1/ According to the Report of the ECA Mission for Economic Co-operation in Central Africa (Provisional Version) conservative estimate, Central African 1975 fertilizer requirement is expected to consist of 24,000 tons N, 15,000 tons $K_2O$ and more or less static phosphate demand.

2/ Investigation on Fertilizer and Chemical Industries in East Africa (E/CN.14/INR/83), ECA, 1965.

TABLE 11

Fertilizer Plants (existing, under construction and proposed) in East Africa

| Producer & location | Product | Capacity (t/y) | Plan for extension | Raw materials availability |
|---|---|---|---|---|
| Tororo Industrial Chemicals and Fertilizers Ltd., (Tororo, Uganda) | Single superphosphate (21 %) | 25,000 | to add* 75,000 | - Phosphate from Sukulu<br>- imported sulphur |
| RODIA of the African Explosives and Chemical Industries (Rhodesia) Ltd. (Salisbury, Rhodesia) | Single superphosphate (19%) | 50,000 | being extended by 10,000 ($P_2O_5$) | - expected to start using local phosphate from Dorowa July, 1965<br>- pyrite to be supplemented by imported sulphur |
| | triple superphosphate (44%) | 50,000 | | |
| 'Soda-phosphate Plant' (Turbo, Kenya) | Soda phosphate (25 %) | 4,000 | | - phosphate from Sukulu<br>- Soda-ash from Lake Magadi |
| Mauritius Chemical & Fertilizer Industry Ltd. (Port Louis, Mauritius) a/ | 12:9:12 complex | 60,000 | Adding 60,000 in due course | - imported ammonia, ammonium phosphate and muriate of potash |
| The Ralph M. Parsons Co. (Danakil Depression, Ethiopia) a/ | Mauriate of potash (60% $K_2O$) | 600,000 | | - sylvinite |
| Nitrogenous Fertilizer Plant at Umtali' (Umtali, Rhodesia) b/ | Ammonium sulphate (21.5 %) | 190,000* | | - petroleum feedstock |
| | Ammonium nitrate (34 %) | 80,000* | | |
| Nitrogenous fertilizer plant in Uganda c/ | Ammonium sulphate (21.5 %) | 190,000* | | - methane from Lake Kivu |
| Single superphosphate plant at Dar-es-Salaam (Dar-es-Salaam, Tanzania) | Single superphosphate (17 %) | 160,000* | | - phosphate from Min Jingu Hills<br>- Imported sulphur |

* Proposed by ECA

a/ Expected to start operation in 1967/68

b/ Capacity of the ammonia unit is 100,000 tons per year and 14,000 tons of the ammonium nitrate is for the manufacture of explosives.

c/ This location may be shifted to Kenya provided methane from Lake Kivu could not economically be used in Uganda.

proposed fertilizer plants are envisaged to meet with the 1970 estimated demands of 120,000 tons N and 95,000 tons $P_2O_5$. As for potash fertilizers, the Danakil Depression (Ethiopia) plant will more than cover the East African requirement even beyond 1980.

98. North Africa - The fertilizer industry in North Africa is the most advanced. Both nitrogenous and phosphate fertilizers are manufactured. With abundant raw material (phosphate, natural gas, petroleum and to some extent potash) reserves available, the sub-region can, with some effort, become a net exporter of phosphate and nitrogenous fertilizers.[1/] This seems to be the goal envisaged from the number of export-oriented projects set forth in Table 12.

99. Comparison of the maximum ammonia capacity (known existing or under construction) with the 150,000 tons per year, considered economically feasible ammonia capacity (in North Africa) for export purpose,[2/] however, shows that export of ammonia (to traditionally nitrogenous fertilizer producing countries and competing with their products in the export market) does not appear to be very promising. This suggests that if nitrogenous fertilizer plants in North Africa are to break through those markets they should have ammonia capacities, well above 150,000 tons It would, in addition, be advisable to start with exporting intermediate chemicals, such as ammonia. Even with intermediates it is essential for North African countries to have assured access to markets before establishing the plants.

100. Examination of the foregoing tables reveals that each sub-region is directly or indirectly concerned with fertilizer projects. If all

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1/ Trends towards hydrocarbon raw materials for ammonia manufacture and tendencies for ammonia and phosphate fertilizer plants to be located near the sources of raw materials could possibly make this sub-region one of the leading producers of nitrogenous and phosphate fertilizers in the world.

2/ Source: Developing the Petrochemical Potentials of North Africa and the Persian Gulf (PET/CHEM/CONF/64), 1964.

TABLE 12

Fertiliser Plants in North Africa (Existing, under construction and planned)

| Country and producer | Location | Year of est. | Products | Capacity (t/y) | Plan for extension | Raw materials |
|---|---|---|---|---|---|---|
| MOROCCO | | | | | | |
| Société Cherifienne d'Engrais et de Produits Chimiques | Ain Sebaa | 1923 | SS (18 %) | 150,000 | | Phosphate, pyrite |
| Productos Quimicos Marroquies+ | Tétouan | 1956 | DCP(35 %) | 2,000 | 5,000 (1960/64) | Phosphate |
| Société Marocaine des Engrais Pulvérisés | Safi, Kenitra Berrechid | 1944 | HP (34 %) | 100,000 | | Phosphate |
| Le Complexe Chimique de Safi | Safi | 1965 | TS (45 %)<br>AN (21 %)<br>DAP(18 %N, 48 $P_2O_5$) | 200,000<br>36,000<br>150,000 | | Phosphate, Pyrrhotine |
| Potash project | | | PC (60 %) | 250,000 | | Carnalite or sylvinite |
| ALGERIA | | | | | | |
| Soc.Algerienne de Produits Chimiques et d'Engrais | Oran, Algiers Philippe-ville | E | SS (18 %) | 90,000 | | Phosphate, Pyrite |
| Société Alger de l'Azote | Arzew | U.C. | AN (33 %)<br>Urea (46 %) | 20,000<br>10,000 | | Natural Gas |
| 'Complexe Petro-chimique+ | Arzew | | Ammonia | 200,000 | | Natural Gas |
| TUNISIA | | | | | | |
| NPK engrais+ | Sfax | 1965 | TS (45 %) | 150,000 | 30,000 (1968) | Phosphate, Sulphur (I) |
| S.I.A.P.E.+ | Sfax | 1951 | TS (45 %) | 170,000 | over 30,000 | Phosphate, Sulphur (I) |
| La Société Tunisienne des Engrais Pulvérisés | Sfax | 1956 | HP (25-30%) | 130,000 | Conversion envisaged | Phosphate |
| S.P.A.C.E.+ | Tunis | 1919 | SS (16 %) | 60,000 | | Phosphate, Pyrite (I) |
| Industries Chimiques Maghrebines | Ghannoud | 1964 | AP (16 %N, 48 % $P_2O_5$) | 200,000 | | Naphtha, Sulphur, |
| | | | AN (20.5 %) | 85,000 | | Phosphate |
| LIBYA | | | | | | |
| 'Petrochemical Complex + | | | Ammonia | 330,000 | | Natural Gas |
| UAR | | | | | | |
| Abu-Zaabal Fertilisers and Chemicals Co. | Cairo | 1948 | SS (15 %) | 70,000 | 116,000 1966 | Phosphate Pyrite (I) Sulphur |
| Société Financière et Industrielle Egyptienne | Kafr el Zayat | 1937 | SS (15 %) | 220,000 | | Phosphate, Pyrite (I) Sulphur |
| Asayut Fertilisers & Chemical Industries Co. | Asayut | 1967 | SS (15 %) | 200,000 | | Phosphate, Sulphur |
| Egyptian Chemical Industries Co. (KIMA) | Aswan | 1960 | CAN(20.5%) | 480,000 | | Water, Limestone |
| Phosphorus Complex | Aswan | 1965/70 | TS (45 %) | 100,000 | | Phosphate |
| Société d'Engrais et d'Industries Chimiques | Suez | 1951<br>1963<br>1968<br>1968<br>1965/70<br>1965/70 | CN (15.5%)<br>AS (20.6%)<br>CN (15.5%)<br>CAN(20.5%)<br>SS (15 %)<br>AS (20.6%)+ | 252,000<br>100,000<br>258,000<br>160,000<br>400,000<br>200,000 | | Refinery gas, Limestone, sulphur, naphtha, gypsum |
| Petrochemical Complex+ | Alexandria | 1965/70 | CAN(20.5%) | 200,000 | | Naphtha Limestone |
| El Naar Co. for Coke & Chemicals | Helwan | 1967<br>1968<br>1965/70<br>1965/70 | CAN(20.5%)<br>CAN(20.5%)<br>Urea (46 %)+<br>CAN(20.5%) | 200,000<br>200,000<br>95,000<br>200,000 | | Coke oven gas, limestone |
| Potash Plant | | 1965/70 | PS | 5,200 | | Mother liquor, ethyl alcohol |
| SUDAN | | | | | | |
| International Development and Investment Co. Ltd. | Port Sudan | | AN (33 %) | 75,000 | | Petroleum feedstock |

Notes: E= Existing, U.C. = under construction, + = export-oriented, SS= single super, TS = triple super, DCP = dicalcium phosphate, HP = Hyperphosphate, AP = ammonium phosphate, DAP = diammonium phosphate, AN = Ammonium nitrate, CAN = calcium ammonium nitrate, CN = calcium nitrate, AS = ammonium sulphate. PC = Potassium chloride, PS = Potassium sulphate

Information on countries other than Tunisia and the UAR is inadequate and some times conflicting. It is, therefore, tentative and subject to correction.

goes well most, if not all, of these projects may be realized before or about 1970. An attempt has been made to classify capacities into: existing, under construction, country project and ECA recommendation. The result of this exercise is presented in Table 13.

TABLE 13

Probable Fertilizer Industry Capacities around 1970 according to sub-regions

(in 1000 tons of pure nutrients)

| | Existing | Under Construction | Country project | ECA recommendation | Total 1970 | 1970 est. potential demand |
|---|---|---|---|---|---|---|
| Nitrogenous (N) | 183 | 252 | 672 | 171 | 1278 | 757 |
| North Africa | 183 | 252 | 672 | - | 1107 | 450 |
| East Africa | - | - | - | 120+ | 120+ | 220 |
| Central Africa | - | - | - | - | - | 40 |
| West Africa | - | - | - | 51+ | 51+ | 47 |
| Phosphate ($P_2O_5$) | 281 | 341 | 166 | 111 | 898 | 598 |
| North Africa | 244 | 341 | 166 | - | 750 | 300 |
| East Africa | 37 | - | - | 58 | 95 | 220 |
| Central Africa | - | - | - | - | - | 25 |
| West Africa | - | - | - | 53 | 53 | 53 |
| Potash ($K_2O$) | - | 720 | 150 | - | 870 | 253 |
| North Africa | - | - | 150 | - | 150 | 75 |
| East Africa | - | 360 | - | - | 360 | 110 |
| Central Africa | - | 360 | - | - | 360 | 25 |
| West Africa | - | - | - | - | - | 43 |

+Includes N for explosive purposes.

101. Comparison of total expected capacities with 1970 estimated potential consumption indicates excess of output over consumption in all three nutrients. From the number of export-oriented projects (Table 12) it appears that about 45 per cent of the N and 36 per cent of the $P_2O_5$ total expected capacities (Table 13) are envisaged for export mainly to countries outside the region. In other words the excesses in N and $P_2O_5$ are apparent as far as the region is concerned. As the 1970 estimated demands are, however, based on potential requirements they may be considered to be on the high side. This would in reality mean that the gap between the practical expected consumption and production will not be as wide as it may appear to be. In other words it is unlikely that Africa will face a major over-all shortage of locally manufactured fertilizers around 1970.1/

102. Grouping capacities by kinds and sub-regions show that North Africa will still be leading the other sub-regions in 1970. About 86 per cent of the N and 84 per cent of the $P_2O_5$ production figures in the above table refer to North Africa. About 83 per cent of the $K_2O$ production will be shared equally between East Africa and Central Africa.

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1/ Admittedly the reliability of the conclusion on the likelihood of the fertilizer industry situation in Africa in 1970 is questionable. It should be considered in the light of the shortcomings, such as those expressed in the footnote of Table 12 and the possibilities that some of the projects may not materialize in time, or never at all.

## V. PESTICIDES (PLANT PROTECTION CHEMICALS)

### Need for pesticides and identification of the important ones

103. As regards agriculture, pesticides are complementary to fertilizers. The latter increase yield directly and the former indirectly by decreasing loss due to insects, weeds, fungui etc. both in the field and storage. It has been estimated that over 13 billion dollars worth of agricultural products are lost annually in the USA because of agricultural pests.[1/] This loss would have been much larger had pesticides not been used. It is, therefore, obvious that pesticides will have to play an important role in increasing the productivity of the African soil.

104. The need for and importance of insecticides for public health and animal husbandry cannot be over-emphasized. Their role in these spheres may be expected to increase considerably with the rising standard of living of the people of the region.

105. The wide variety of pesticides (literally thousands of them appearing in the form of liquids, dusts, wettable powders and emulsions) present in the market, the relatively small quantities of individual pesticides used and the inadequate information available on their use in the region call for further investigation. As it would not be practical to consider the very large range of pesticides in use it would be necessary to limit the range or even select the basic pesticides (technical grades) that may have possibilities in the region.

106. It appears that insecticides are, in general, the most important pesticides in the region. A huge number of chlorinated hydrocarbons, organo-phosphorous insecticides, sulphur compounds, lead arsenate, pyrethrum etc. are in use. The first group, DDT and BHC in particular, are the most significant in a number of countries in the region. This has been and is still the case in many parts of the world. The 1954 production situation in the USA could be cited in support of the above

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1/ Source: Shreve, R. Norris, The Chemical Process Industries, 2nd Ed., Mc Graw-Hill Book Company Inc., N.Y., 1956.

statement. Out of the 419 million pounds produced 23.2 and 18.4 per cent represented DDT and BHC respectively. This situation applies to developing countries as well. Production of technical grade pesticides in a number of developing countries in Asia is, for instance, limited to DDT and BHC.

107. Why do DDT and BHC appear to be the most popular insecticides? Firstly, both of them are used for both plant and animal protection. This combination of application means convenience and relatively larger volume of sales with all the advantages resulting thereof. Secondly, because of their properties, they are, to some extent, comparatively easier to manufacture and apply and cheaper than many insecticides. Thirdly, as they have a broad control spectrum, the scope of their application is comparatively large thereby reducing the number of types of insecticides to be used.

Demand for and production and formulation of pesticides

108. Identifying the most important insecticides is one thing and estimating present and future demand is another thing. As far as insecticides are concerned, imports, if available, can be equated for consumption. Unfortunately statistical data rarely show a breakdown of imports by types of pesticides, leave alone distinguished individual items, such as, DDT and BHC. The data given in Table 14 for East and West Africa were collected mainly from importers and dealers of pesticides.

109. The present and future demand situation with respect to Central and North Africa is less known. No attempt has been made in this paper to indicate orders of magnitudes for there are no adequate background information on which rough estimates could be based.

110. As regards production of pesticides it is known that there are a number of pesticides establishments in the region. Information on their activities are, however, scanty. With the possible exception of a DDT plant of 600 tons capacity in the UAR and a sodium arsenate plant of 220 tons arsenate capacity all of these establishments are formulating plants depending on imported basic materials. These formulating plants are the forerunners of those that may be expected to be set up to produce some of the technical grades synthetic pesticides.

TABLE 14

Present and probable production and consumption by 1970 of DDT and BHC on a sub-regional basis

(in tons)

| | Present | | | 1970 | | |
|---|---|---|---|---|---|---|
| | Consumption | Production | Capacity | Estimated demand | Capacity envisaged | Remarks |
| DDT | | | | | | |
| North Africa | .. | 300 | 600 | .. | .. | |
| East Africa | 1880 | .. | - | 5250 | 5500 | 75 % |
| Central Africa | .. | - | - | .. | .. | |
| West Africa | 5400 | - | - | 8000 | 8000 | 50 % |
| BHC | | | | | | |
| North Africa | .. | - | - | .. | .. | |
| East Africa | 1790 | - | - | 3480 | 7000 | 25 % (Ca.for 1975) |
| Central Africa | .. | - | - | .. | .. | |
| West Africa | 10800 | - | - | 15000 | 15000 | 25 % |

111. The production situation in the preceding paragraph refers to inorganic and synthetic insecticides only. The region is a leading producer of one plant derivative insecticide, that is, pyrethrum flowers and extract. In 1961 African production accounted for 65 per cent of world output of 11,000 tons dried flowers. In the same year Kenya alone exported 2,540 tons flowers and 296 tons extracts from two existing plants. Other countries producing pyrethrum are Congo (Leo.) and Tanzania.

112. Pyrethrum is non-toxic to man and warm blooded animals. It has a quick knowckdown effect on flies but it is not persistent. It is mainly

used in insecticide formulations for fly sprays as an aerosol for household purpose. Unlike synthetic insecticide, insects have as yet not shown tendency for developing resistance to pyrethrum. All these properties coupled with the fact that no economic synthetic substitute has so far been found for pyrethrum indicate that pyrethrum will continue to play its role as an important export item of the East and Central African sub-regions.

Measures for promoting use of pesticides

113. As is the case with fertilizers, government action is imperative if farmers are to benefit from pesticides. All measures and policies which are used and may be expected to be used to promote the use of fertilizers should be applicable to pesticides as well. Both fertilizers and pesticides can be handled by the same organizations, institutions and people promoting the application of fertilizers.

## VI. BASIC CHEMICALS

114. Sulphuric acid - Due to the existence of fertilizer industries, super-phosphates in particular, sulphuric acid production has been substantial. Installed capacity should be of the order of magnitude of 954,000 tons, 32 per cent of which is for uses other than fertilizers. About 60 per cent of the total capacity is in North Africa and 26 and 14 per cent in East and Central Africa respectively (table 15).

115. A number of existing sulphuric acid facilities are undergoing extension. This coupled with those under construction will, in a matter of about two years, raise the total present capacity to the order of 1.9 million tons. North Africa will account for almost all of the increase.

116. With more fertilizer and other sulphuric acid consuming projects envisaged, capacity may be expected to increase to over 3 million tons in 1970. This relatively large increase confirms the importance of sulphuric acid as the 'grandfather of all business indicators.'

117. In terms of sulphur the 1970 expected capacity of sulphuric acid is equivalent to over 1 million tons. As brimstone is almost non-existent and as availability of pyrites is so far limited, most of the future sulphuric acid plants will have to depend on the supply of imported sulphur. This, of course, means a big burden to the sulphuric acid plants. In view of this situation and the rising trend of world sulphur prices (because of decreasing availability), it would be advisable to consider the putting into use of other sulphur bearing materials and investigate possibilities for substituting other acids for sulphuric acid in some fields of applications.

118. Sulphuric acid from gypsum (anhydrite) is technologically feasible provided there is a market for the acid and the cement that is obtained as a co-product. Countries with gypsum deposits and a cement industry not yet developed would do well to consider the sulphuric acid-cement approach. This approach lowers the high capital cost per unit of the acid by sharing it with that of the cement.

119. Another way of using gypsum is in the manufacture of ammonium sulphate. In the gypsum-sulphate process or the Merserberg Process, as it is called, gypsum is directly reacted with ammonium carbonate resulting in ammonium sulphate and calcium carbonate. As was the case with the sulphuric acid from gypsum, combining this process with the manufacture of cement is a necessary condition for its success. This process is currently being used in United Kingdom and India. The Fertilizers and Chemicals, Travancore Ltd., of the latter country has recently succeeded in utilizing by-product gypsum instead of natural gypsum. This development is a welcome for those countries with no resources of sulphur bearing materials. It will enable them to reduce importation of sulphur as by-product gypsum from a phosphoric acid plant can be utilized in the manufacture of ammonium sulphate.

120. Sulphur dioxide from smelters is another source for sulphuric acid. Both Congo Leo., and Zambia have sulphuric acid plants with a combined capacity of over 230,000 tons per year based on smelter gases. Countries with similar possibilities should explore the economies of using smelter gases before deciding on other sources of sulphur.

121. At one time the presence of sulphur in natural gas or crude petroleum was considered a disadvantage. This is no longer the case. Take the example of the Lacq natural gas field in France. The gas contains 15.2 per cent hydrogen sulphide whose sulphur is extracted at the gas processing plant at Lacq. About 1.4 million tons of sulphur is recovered annually thereby making France a large producer of sulphur.

122. African natural gases and crudes, most of them at least, unfortunately, do not appear to offer this kind of prospect. They are either sweet or contain very little sulphur. It is of interest to note here that the UAR does recover over 30,000 tons of sulphur per year from its refineries. African countries with similar prospects as that of the UAR would be advised to follow the example.

123. Turning to the question of substitute acids it is encouraging to note here that some success has already been observed. The Israel Mining Industries, Institute for Research and Development has, for instance,

developed a process for phosphoric acid making using hydrochloric acid as an acidulant with subsequent solvent extraction of the resulting phosphoric acid. The phosphoric acid produced is said to be comparable to thermal acid in both quality and concentration. This new process is under operation in Japan, under construction in Brazil and may, therefore, prove practical in countries in the region with excess hydrochloric acid disposed of at reasonable prices. If successfully implemented this would partially do away with sulphur and at the same time solve the problem of excess chlorine that would be inevitable if the chlorine-caustic industry is to develop to satisfy demand for caustic soda.

124. Research on the use of nitric acid as an acidulant for phosphate rock does not appear to have been as successful as in the use of hydrochloric acid. A successful application in substituting nitric acid for sulphuric acid will mean a lot especially to those countries with large petroleum or natural gas resources.

125. Caustic soda - After sulphuric acid caustic soda is probably the basic inorganic chemical with the widest application both in the chemical and other industries in the region. Soap, alumina, textiles, vegetable oils, pulp and paper, petroleum refining and rayon have been the major consumers in Africa so far.

126. The UAR, Morocco and Algeria are the only producers of caustic soda, their joint production in 1964 totalling about 22,000 tons, total capacity being equal to over 33,000 tons (Table 15). African demand in excess of production was met by imports, East, Central and West Africa importing about 13,000, 5,000 and 48,000 tons respectively. From available information, 1970 capacity of caustic soda may be expected to be over 90,000 tons. The potential requirement will, of course, exceed this for the estimated consumption (excluding additional requirements for new aluminia plant) is of the order of magnitude of 300,000 tons.[1/]

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1/ The alumina plant in Guinea is the biggest single consumer of caustic soda (30,000 tons). The viscode rayon plants and pulp and paper mills envisaged will account for the major part of the increase in the region.

127. Technically potential demand can be met provided the large excess of chlorine that may result from salt electrolysis plants could be disposed of economically. Unlike in the developed countries where chlorine demand exceeds that of caustic soda, the over-all situation in the region is just the opposite. This unfavourable situation will undoubtedly improve with the development of the important chlorine consuming industries, such as, plastics, insecticides, solvents, pulp and paper and textiles. Until such a time is reached, economic utilization of chlorine will be the main limiting factor for the development of the chlorine-caustic and related industries.

128. Causticization of soda ash (lime-soda process) is an alternative for caustic soda production. It does not involve chlorine as a by-product. Unfortunately according to a preliminary investigation in connexion with Lake Magadi (Kenya) natural soda ash, cost of production per unit is said to be substantially higher than for the process involving the electrolysis of salt.[1/] Within the last ten or twenty years, because of the progressively higher demand for chlorine, the change over to salt electrolysis was effected. At present over 90 per cent of the caustic soda in developed countries is obtained from salt electrolysis. In view of the completely different situation in developing countries existing at present, countries with natural soda ash deposits would be advised to prove conclusively the unfavourable statement made above on the higher cost of production before embarking on production of caustic soda based on salt electrolysis.

129. Chlorine - As was stated earlier outlet for chlorine in the region is very limited at present. Excluding the UAR, Algeria and Morocco with a combined production of about 20,000 tons per year, production or for that matter consumption is not significant. This situation will continue as long as the chlorine consuming industries are not developed to a relatively large scale.

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1/ Investigation on Fertilizer and Chemical Industries in East Africa (E/CN.14/INR/83), ECA, 1965.

130. The realization of the proposed chlorine-caustic plants (19,000 tons for East Africa and 18,000 tons for West Africa together with the Algerian planned expansion by 12,000 tons may be expected to raise the present capacity of approximately 29,000 tons to 80,000 tons in 1970. This capacity could be much higher provided sulphuric acid could economically be replaced by hydrochloric acid in acidulating phosphate rock.

131. Soda ash - Current consumption figures (even their order of magnitude) of soda ash in the region are not available. In addition to this paucity of information the interchangeability of soda ash and caustic soda in many fields of application makes estimation of soda ash consumption the more difficult. Presumably the major consumer is the glass industry. Soda phosphate, soap, petroleum refining and textiles are among the others.

132. Economies of scale for a Solvay process are rather high and this partly explains why there has not been a single Solvay plant in any of the sub-regions as yet. Before or by 1970 both the UAR and Morocco expect to operate Solvay plants with installed capacities of 100,000 and 18,000 tons respectively.

133. A relatively new development for soda ash production is the dual process. This is a modified Solvay process in which no limestone is used and ammonium chloride is produced as a co-product. This process is successfully used in Japan and China (Taiwan) where ammonium chloride has been found to be suitable as a fertilizer for rice. It may be adapted in Africa provided a market is available for ammonium chloride.

134. The preceding paragraphs may have given the impression that the region depends entirely on imported soda ash. This is not so. Soda ash from Lake Magadi in Kenya has been exploited for years. It reached maximum production of 147,000 tons in 1961. As a result of the economic sanctions against South Africa, Kenya's largest buyer of soda ash; export and consequently output of soda ash is on the decline. In all likelihood the rising demand of soda ash in other African countries will, in not too distant a future, enable Kenya to revive and further develop the soda ash industry.

135. Although perhaps not as promising as that of Lake Magadi, Lake Chad in Chad is another known source of natural soda ash. Its current production is around 8,000 tons per year. It would be advisable to investigate the feasibility of a large-scale exploitation of soda ash from this lake. The importance of this investigation for Chad and the West African sub-region cannot be over-emphasized.

136. Ammonia - This basic chemical is the starting point for the manufacture of nitrogenous fertilizers and other nitrogen chemicals. At present the UAR is the only country in the sub-regions producing ammonia. Present capacity utilization is 83 per cent of the total installed capacity of 223,000 tons (table 15). All of the output is used captively in the production of fertilizers.

137. A large expansion of this industry in the UAR is foreseen by 1970. Both Algeria and Libya are planning for large scale ammonia projects modelled on that of Trinidad for export purpose mainly. According to ECA recommendations both East and West Africa are expected to go ahead with the establishment of ammonia plants. The realization of all these plans, projects and recommendations will raise the present installed capacity by sevenfold to 1.55 million tons by about 1970.

138. With the exception of the existing Aswan ammonia unit based on water electrolysis in the UAR, ammonia plants in the region will possibly be based on natural gas and petroleum feedstocks. This is to say that the trend towards hydrocarbon feedstocks will, in all probability, manifest itself in the ammonia plants to be built in the future in the region.

139. Within the last few years capacities of ammonia synthesis plants installed in developed countries have gone up beyond the limit that would be possible for the small demand in developing countries. Single train units of 1,000 tons per day and over are becoming common. Due to cost advantages arising from such economies of scale developed and some developing countries are expected to lower prices of ammonia. Further development of tanker transportation is another factor that may further reduce the price of ammonia.

140. This trend of falling prices may have an adverse effect in retarding, if not stopping, the establishment of ammonia plants in many developing countries. This will in turn deprive these countries of a number of industrial activities that could be induced by the presence of ammonia plants. Who knows what will happen next? New developments may result in widening the gap in the cost of production. What then? If a 'wait and see' approach is adapted, no developing country may be able to manufacture this basic chemical.

141. Fortunately small package ammonia plants with capacities ranging between 60 and 100 tons per day have been developed recently. These turn-key low priced plants are nowadays being manufactured by some firms in the USA. These are, of course, not very good substitutes for big plants designed to serve a number of countries. In view of the declining trend of ammonia prices it may, in the long run, pay to put up few large ammonia plants than many small ones.

TABLE 15

Production and Current and Future Capacities of Sulphuric Acid, Caustic Soda and Ammonia in the Sub-regions

(in 1000 tons)

| Sub-region and Country | Sulphuric acid (100%) | | | | | | Caustic Soda (100%) | | | | | | | Ammonia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Capacity | | | | | | Capacity | | 1970 est. consumption | Capacity | |
| | 1954 | 1957 | 1960 | 1963 | Current | 1970 | 1954 | 1957 | 1960 | 1963 | Current | 1970 | | Current | 1970 |
| NORTH AFRICA | 143 | 171 | 190 | 164 | 571 | 1787 | 4.1 | 5.0 | 5.7 | 19.9 | 33.0 | 50.0 | 150 | 223 | 1340 |
| Algeria | 48 | 41 | 40 | 32 | 47 | 47 | 2.5 | 2.0 | 2.2 | 2.2 | 5.0 | 18.0 | | - | 200 |
| Morocco | 38 | 30 | 33 | 36 | 50 | 460 | .. | .. | .. | .. | 3.8 | 3.8 | | - | |
| Tunisia | .. | .. | .. | .. | 200 | 673 | - | - | - | - | - | .. | | - | 60 |
| Libya | - | - | - | - | - | - | - | - | - | - | - | - | | - | 330 |
| UAR | 57 | 89 | 103 | 88 | 260 | 593 | 1.6 | 3.0 | 3.5 | 17.7 | 24.0 | 28.0 | | 223 | 720 |
| Sudan | - | - | - | - | - | - | - | - | - | - | - | - | | - | 30 |
| Canary Islands | .. | 11 | 14 | 13 | 14 | 14 | - | - | - | - | - | - | | | - |
| EAST AFRICA | .. | .. | .. | .. | 252 | 694 | - | - | - | - | - | 21 | 50 | - | 150 |
| Kenya | - | - | - | - | - | 160 | - | - | - | - | - | | | - | 50 |
| Uganda | - | - | - | - | 10 | 40 | - | - | - | - | - | | | - | - |
| Tanzania | - | - | - | - | - | 64 | - | - | - | - | - | | | - | - |
| Zambia | .. | .. | .. | .. | 120 | 120 | - | - | - | - | - | | | - | - |
| Rhodesia | .. | .. | .. | .. | 122 | 270 | - | - | - | - | - | | | - | 100 |
| Other Countries | - | - | - | - | - | 40 | - | - | - | - | - | | | - | - |
| CENTRAL AFRICA | 84 | 123 | .. | 94 | 136 | 136 | - | - | - | - | - | | 5* | - | - |
| Congo (Leo) | 84 | 123 | .. | 94 | 132 | 132 | - | - | - | - | - | | | - | - |
| Gabon | - | - | - | .. | 4 | 4 | - | - | .. | - | - | | | - | - |
| WEST AFRICA | - | - | - | - | - | 340 | - | - | - | - | - | 20 | 90 | - | 62 |
| Nigeria | - | - | - | - | - | 174 | - | - | - | - | - | | - | - | 62 |
| Togo | - | - | - | - | - | 50 | - | - | - | - | - | | | - | - |
| Senegal | - | - | - | - | - | 70 | - | - | - | - | - | | | - | - |
| Other countries | - | - | - | - | - | 46 | - | - | - | - | - | | | - | - |
| Total (Sub-regions) | .. | .. | .. | .. | 959 | 2957 | .. | .. | .. | .. | 33 | 91 | 295 | 223 | 1552 |

Source: Statistical Yearbook, UN, 1964 and National Publications.

Note: 1970 capacities were computed from the requirements of the basic chemicals for industries (existing, under construction, recommended by ECA and planned) expected to be in operation around 1970.

* Present consumption.

## VII. PETROCHEMICALS

### What are petrochemicals?

142. Organic chemicals may be defined as hydrocarbon chemicals and their derivatives or as carbo-chemicals. They are derived from raw materials of hydrocarbon (petroleum, natural gas), coal and vegetable origins. Those originating from petroleum and natural gas are known as petrochemicals.

143. Aliphatics (paraffins and olefins) and aromatics are the basic intermediates for the petrochemical industry and ethylene, acetylene, butadiene and benzene among the most important intermediates. Some of the organic chemicals, aromatics in particular, used to be made and are still being made in some countries as by-products of cokeries, coal tar industry and from raw materials of vegetable origin.

144. Petrochemicals may be broadly classified into the following categories:

1. Ammonia and nitrogenous fertilizers
2. Plastics
3. Synthetic fibres
4. Synthetic rubbers
5. Others (benzene, tolouence, detergents, insecticides, solvents, acetone, carbon black, sulphur etc.)

### Importance of petrochemicals

145. The scope of the petrochemical field is extensive and is expanding from day to day. New products are being put in the market and new uses found for the old ones. Traditional materials, such as, natural rubber, natural fibres, soap, paper, wood, aluminium and steel have been and are still been replaced by petrochemicals in many fields of application. In short the petrochemical industry is a strategic industry which by its nature induces further economic development.

146. Basic organic chemicals are increasingly being manufactured from products of petroleum and natural gas origin. In Western Europe basic organic chemicals (petrochemicals) obtained from petroleum and natural gas accounted for 58 per cent and those from coal 39 per cent in 1962. It is in the USA, however, that the shift from coal and other sources to petroleum and natural gas raw materials has been spectacular. The 1962, 58 per cent share in Western Europe was attained in 1950 in the USA. This rose to 85 per cent in 1960 and 93 per cent in 1962. In terms of per cent of total chemical production the share of petrochemicals increased from 5 in 1935 to 20 in 1950 and 32 in 1960 in the USA. In 1970 it is expected to reach 50.1/

Possibilities for petrochemical industries in the region

147. Inspite of the problems involved in establishing petrochemical plants in developing countries, some of these countries (with raw material resources), realizing the increasingly important role of the petrochemical industry in economic development, have embarked on the development of this sector. Recent experiences, that of Trinidad for example, have shown the tendency for petrochemical (mainly intermediate ) plants to be located near the source of raw material. It appears that the majority of the few petrochemical projects that are being planned or considered by some African countries are to be modelled on that of Trinidad.

148. Out of the 61 petrochemical plants reported for the developing countries in 1963 one only was being put up in Africa. The situation with projects in the same year was no better, Africa's share being 4 out of 70.2/

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1/ Sources: The Chemical Industry, OECD, 1962-63 and Waddams, A.L., Chemicals from Petroleum, Shell Chemical Co., Ltd., 1962.

2/ Source: General Characteristics of Petrochemical Industries and Factors Conditioning their development (PET/CHEM/CONF.115), Centre for Industrial Development, 1964.

149. From tables 12 and 16 it appears that the number of plants and projects reported above for Africa were on the low side. The number of existing plants should have been more than three. Assuming all studies and recommendations under consideration as projects, the number of projects comes to about five or more.[1/] As may be expected most of these plants and projects are for the production of ammonia and its derivatives.

150. As most of the relevant information on the individual plants and projects is given in the tables mentioned above, it may not be necessary to discuss each one of them. A few words may not, however, be out of place with regard to some of them.

151. The petrochemical projects under consideration in Algeria are to be geared to develop stage by stage. They are expected to start producing mainly basic intermediates: ammonia, methanal, $C_4$ - out and polypropylene for export. Further processing to PVC, nitrogenous fertilizers and possibly acrilonitrile for local consumption is envisaged. The latest available information concerning these projects is that the special Fund has committed itself to contribute $ 835,000 for a further study of these projects.[2/]

152. Unlike the projects in Algeria that in the UAR, it appears, is based mainly to satisfy local demand. In other words the UAR project (which is the most advanced) has as its goal to carry the processing further so as to produce more consumer products as shown in table 16.

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1/ Excluding plants and projects in South Africa.

2/ Source: Marchés Tropicaux et Méditerranéens, 11 September 1965.

TABLE 16

Petrochemical complexes (excluding nitrogenous fertilizers)

| | Year of est. | Location | Product | Capacity | Remarks |
|---|---|---|---|---|---|
| Algeria | | | | | |
| Complexe Petrochimique (preliminary study) | | Arzew | Ammonia * | 200,000 | from natural gas |
| | | | methanol * | 66,000 | |
| | | | acetylene | 9,000 | |
| | | | PVC * | 20,000 | |
| | | Alger | propylene | 30,000 | from cracking 200,000 tons of naphta from refinery at Algiers |
| | | | $C_4$- Cut * | 20,000 | |
| | | | Polypropylene or | 27,000 | |
| | | | acrilonitrile * | 12,600 | |
| | | | polypropylene * | 18,000 | |
| | | | or | | |
| | | | polyethylene | 19,500 | |
| | | | or | | |
| | | | ethylene-propylene | 20,000 | |
| | | Cue de Constantine | Calcium ammonium nitrate | 100,000 | 26 per cent N |
| | | | or | | |
| | | | ammonium sulphate-nitrate | 100,000 | 26 per cent N |
| | | | or | | |
| | | | N.P.K. complex | 150,000 | |
| AR | | | | | |
| Petrochemical Complex at Alexandria (Project prepared by SNAM for the General Organization for Executing the Five Year Industrial Plan, Jan., 1965) | 1969 | | Polyethylene | 15,000 | from steam cracking of light naphtha |
| | | | PVC | 20,000 | |
| | | | Phenol | 6,000 | |
| | | | acrylonitrile | 5,000 | for polyacrylonitrile |
| | | | caprolactam | 4,000 | fibers for nylon 6 |
| | | | polybutadiene | 12,000 | for synthetic rubber |
| | | | calcium ammonium nitrate | 200,000 | 20.5 per cent N |
| | | | methyl alcohol | 10,000 | for formaldehyde |

* Recommended for first stage production.

153. The Libyan project for which plans have been submitted by international oil companies consists of provisions for the liquefaction of associated gas and ammonia synthesis for export. Information on ammonia capacity recommended by these companies have not been made public, although a capacity of about 330,000 tons has been reported by a different source.

154. Complexes reported to be under construction in both Morocco and Tunisia are relatively simple compared to those of the UAR and Algeria.[1] Their end products are nitrogenous fertilizers partly for home consumption and partly for export.

155. In accordance with ECA recommendations Nigeria, Rhodesia and Kenya or Uganda may be expected to go ahead with nitrogenous fertilizer projects.

156. In addition to the nitrogenous fertilizer industries for East and West Africa, ECA studies have made proposals for other petrochemicals: PVC, polyethylene, DDT and BHC. The 1970 probable situation of PVC and polyethylene in the region have been summarized in table 17.[2] According to this table total regional capacities of 50,000 tons PVC and 35,000 tons polyethylene may be expected in the early 1970's. The latter two, DDT and BHC, have already been discussed in the section on pesticides.

157. Finally it is worth mentioning here that some organic chemicals are recovered as by-products of cokeries. Benzol, toluol, naphtha, naphthalene, tar and pitch are, for example, produced in Rhodesia and benzol, toluene, xylene, phenol, ammonium sulphate and coal tar in the UAR.

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1/ The Safi complex in Morocco is to obtain its ammonia requirement from the Arzew plant in Algeria.

2/ Figures for East Africa are considered to be on the low side.

TABLE 17

Present and probable production and consumption by 1970 of PVC and polyethylene on a sub-regional basis

(in tons)

| | Present | | | 1970 | | Remarks |
|---|---|---|---|---|---|---|
| | Consumption | Production | Capacity | Estimated demand | Capacity envisaged | |
| PVC | | | | | | |
| North Africa | .. | - | - | .. | 40,000 | UAR & Algeria |
| East Africa | 3,280 | - | - | 6,800 | 7,000 | 60% PVC? |
| Central Africa | .. | - | - | .. | - | |
| West Africa | 5,800 | - | - | 9,000 | 9,000 | 60% PVC |
| Polyethylene | | | | | | |
| North Africa | .. | - | - | .. | 15,000 | UAR only |
| East Africa | 3,500 | - | - | 10,700 | 20,000 | 1973/74 capacity |
| Central Africa | .. | - | - | .. | - | |
| West Africa | 3,800 | - | - | 8,000 | - | |

## VIII. OTHER CHEMICALS

158. This section deals with some individual chemicals and chemical products not included in the preceding sections. These have been selected from a huge number of chemicals that are consumed in Africa. Their present and future market sizes or their importance in and impact on the development of the economy as a whole or their role in import substitution or the advantages they give rise to integration are some of the criteria used in their selection. As some of them are heavily dependent on basic chemicals as raw materials or supplies, their development, like that of the fertilizer industry, is a big factor in promoting the basic chemical industry. With these basic concepts as background, brief discussions on the following are presented herewith.

159. Industrial Explosives - The mining industry is the biggest consumer of industrial explosives in Africa. Zambia with the largest mining activities in the East African Sub-region, for instance, accounted for 70 per cent of the 1964 import of the sub-region. Most of the remaining (26 per cent) went to Rhodesia, another country with a well developed mining industry. In Central Africa Congo Leo., the leading country in mining activities, imported 1,362 tons in 1962 and produced 4,604 tons in 1963 indicating a consumption of the order of magnitude of 6,000 tons. In general this situation is applicable to the other sub-regions.

160. Quarrying and construction of roads, railroads, dams and buildings are other sectors of industry requiring industrial explosives. These and the mining industry practically account for almost all of the industrial explosives consumed in Africa. Because of lack of information on some sub-regions the magnitude of this consumption is not known for all sub-regions. It is expected that 1970 demand for East Africa will increase from 21,300 tons in 1964 to 28,400 tons and that of West Africa from 7,300 tons to 10,300 tons.

161. The break-up of industrial explosives according to types is virtually impossible. In West Africa dynamite is the most important type and is said to represent about 90 per cent of imports. In East Africa the oil-bound ammonium nitrate explosive is replacing conventional explosives and is expected to substitute them to the extent of 55 per cent. This would mean that 55 per cent of the 1970 requirement for explosives (15,000 tons) will be met by oil-bound ammonium nitrate. Assuming that the same conversion factor will apply to West Africa as well, the oil-bound ammonium nitrate explosive requirement for West Africa could come to 5,700 tons in 1970.

162. Preparing an oil-bound ammonium nitrate explosive involves relatively simple processes. Its manufacturing facilities may be integrated with an ammonium nitrate plant and this is the case that has been proposed for West Africa. It is assumed that this explosive could be produced most economically in the nitrogen complex recommended in Nigeria.

163. As for East Africa there is already a plant in operation in Zambia. This plant is at the moment getting its ammonium nitrate from outside the sub-region. Its capacity is 1,000 tons per month, almost 80 per cent of the 1970 expected total consumption of this explosive in the sub-region.[1/]

164. Viscose rayon - According to Industrial Growth in Africa,[2/] consumption of rayon in the region increased from 171 million square yards in 1948 to 820 million in 1955 and 942 million in 1960. Demand for rayon in 1970 has been estimated by the same source to be in the neighbourhood of 1,521 million square yards. This is equivalent to 167,000 tons. Using 1960 distribution pattern, 1970 consumption by sub-regions may look like that in the last column of Table 18.

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1/ The possibilities for the manufacture of accessories, such as, fuses and detonators should be investigated when considering projects on industrial explosives.

2/ Source: Industrial Growth in Africa (E/CN.14/INR/1), ECA, 1962.

TABLE 18

Rayon market (1960) and forecast for 1970

| Sub-regions | 1960 consumption | | | 1970 demand | | |
|---|---|---|---|---|---|---|
| | Million sq.yds. | Tons | % | Million sq.yds | Total tons | Viscose rayon tons |
| North Africa | 280 | 30,500 | 29.3 | 445 | 49,000 | 38,000 |
| East Africa | 174 | 18,900 | 18.2 | 276 | 30,400 | 24,000 |
| Central Africa | 36 | 3,920 | 3.8 | 58 | 6,350 | 5,000 |
| West Africa | 179 | 19,500 | 18.7 | 285 | 31,250 | 24,000 |
| Other countries | 287 | 31,200 | 30.0 | 457 | 50,000 | 39,000 |
| Total | 956 | 103,020 | 100.0 | 1,521 | 167,000 | 130,000 |

165. As shown in the above table, with the exception of Central Africa, the 1960 level of sub-regional consumption is high enough to justify one or more rayon plants in each sub-region. It would, however, be necessary, if possible, to examine the types of rayon products marketed in Africa before arriving at any definite conclusion. The only indication available so far is concerning East Africa. Rayon consumption in East Africa is made up of 2/3 continuous filament and 1/3 discontinuous filament (staple fibre). The major part of the former is in the form of fabric and other finished products. As it will, probably, not prove economical to produce all varieties of rayon types and goods in the market within the foreseable future, it does not appear advisable to aim at satisfying demand to the extent of 100 per cent from local production. Assuming 10 per cent of the rayon to represent acetate and cuprammonium and 13 per cent allowance for viscose rayon goods that may not be available from local factories, 77 per cent of the 1970 estimated consumption may be met from local production of 130,000 tons of viscose rayon. In terms of new capacity this is about 120,000 tons.

166. Partly because of the complex nature of the processing technique and the voluminous and varied inputs involved, the viscose rayon industry has not yet established itself in the region. The only output recorded in the 1964 issue of statistical yearbook is that of the UAR which in 1963 produced 6,500 tons of continuous filament and 4,900 tons of discontinuous filament.

167. The viscose rayon industry is a major consumer of the two most important basic chemicals: sulphuric acid and caustic soda. In terms of 100 per cent concentration about 1.3 tons sulphuric acid and 0.7 tons caustic soda are required to make one ton of viscose rayon. If the total new capacity of viscose rayon is to be realized the sulphuric acid and caustic soda requirements would amount to 160,000 and 85,000 tons respectively. It is, therefore, clear that this industry depends heavily on the availability of these chemicals locally. In other words it is an industry which promotes the development of the basic chemical industry.

168. The other major inputs are carbon disulphide and cellulosic materials (wood pulp or cotton linters if available in sufficient quantity and at reasonable price). The former can be made locally using charcoal and imported sulphur. As regards the cellulosic material, the region has not yet developed conditions for the continuous supply of suitable source for the making of dissolving pulp. Until such time the viscose rayon industries in Africa will have to be based on imported pulp. In developing local dissolving pulp supply, account should be taken to integrate pulp projects to supply both the pulp and paper and viscose rayon industries. This idea of integration which is practised in developed countries should be brought to the attention of those working on pulp and paper projects.

169. Calcium carbide - Calcium carbide is an intermediate compound for the making of acetylene which is mainly used as fuel in cutting and welding and in manufacturing PVC. In Africa at present the latter field of application is non-existent, at least in the four sub-regions.

As PVC is increasingly being derived from petrochemical feedstocks, the utilization of calcium carbide as a raw material for PVC making may not be expected to develop appreciably.

170. From the preceding paragraph it seems that calcium carbide is mostly, if not entirely, used to produce acetylene for cutting and welding purposes in industrial establishments and construction works.[1/] Its role in this field of application may be expected to continue and grow for the following reasons. First it is more convenient to transport calcium carbide than acetylene, say, obtained as a petrochemical. Secondly almost every country in Africa has one or more acetylene plants based on calcium carbide. It is clear that these plants will have to be supplied with calcium carbide. Both of these facts then indicate the need for calcium carbide plants in the region.

171. Information on calcium carbide consumption is scanty. Current East African consumption has been estimated to be over 2,200 tons and is expected to increase to 3,500 tons in 1970. In 1964 West African Consumption was in the neighbourhood of 5,500 tons. This is estimated to increase to 7,500 tons in 1970. The situation in the other sub-regions and countries is not known except that the UAR is excepted to put into operation a 5,000 tons plant in 1966. This plant will be expanded to 7,000 tons which is the expected consumption in 1970. In view of the faster development that is to be expected in industrialization and construction works, however, consumption of calcium carbide will surely increase substantially in the region.

172. Aluminium sulphate - This chemical is mainly used in paper sizing and water purification. At this stage the latter field of application is the more important, at least in most countries in Africa. Here again some partial information is available on East and West Africa only. It has been estimated that 1970 East African demand for water purification is about 6,300 tons and that of West Africa 10,000 tons.

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1/ In countries like Nigeria, Calcium Carbide is used as an agricultural spray as well. The continuation of its use is, however, doubtful.

173. At the moment East Africa appears to be the only sub-region producing aluminium sulphate. The aluminium sulphate unit is an integral part of the RODIA phosphate fertilizer plant in Salisbury, Rhodesia. Its capacity of 7,000 tons per year is presently being utilized to the extent of 70 per cent. As aluminium sulphate producing facility can readily be incorporated with a sulphuric acid unit in a country with a source of bauxite, it is possible for each sub-region to establish one or more units. Because of the UAR project for an 18,000 tons unit planned to start operation within the 1965-70 period, the North African sub-region will, in all likelihood, be the first among the remaining sub-regions to produce this chemical. As ferric chloride from a 4,500 tons capacity plant is being used for water treatment in the UAR, aluminium sulphate units have been envisaged to meet with the requirement of the paper industry mainly.

174. Sodium xanthate - This chemical whose demand or application is limited to Zambia and to some extent Rhodesia is used as a floatation agent in the treatment of non-ferrous metal ores. Present demand for it is in the neighbourhood of 2,000 tons per year. As no major increase is expected in the future a capacity equal to the present consumption has been recommended.

175. As carbon disulphide is a raw material for sodium xanthate making and as a production unit of the former is part of the viscose rayon industry, the incorporation of the xanthate manufacturing unit with the viscose rayon industry could prove to be advantageous. This is actually what has been recommended.

176. Tanning materials - Demand for both vegetable and chrome tanning materials will increase substantially with the increasing local tanning and processing of hides and skins which are nowadays exported in large quantities. Wattle bark and extract are export items of the East African sub-region, export of the latter amounting to 36,000 tons in 1961. Growing the wattle tree in North Africa, does not appear to have met with success.

177. Another tannin yielding tree of significance to the region is mangrove. It occurs in both the eastern and western coastal areas. In the former area, Tanzania and Madagascar in particular, tan-bark has been exploited for years. Because of lower average tannin content, considerably below 30 per cent, export of mangrove bark extract from the latter area is said to be not as promising as that from the eastern area with a tannin content well above 30 per cent.[1/]

178. Sant pods and tizra are other vegetable tanning materials of significance in the region. The well known Kano and Morocco leathers are the results of tanning with the former and the latter respectively.

179. Because of change in tanning technique resulting from a better understanding of the tanning process, it is nowadays possible to utilize a vegetable tanning material to produce the same type of leather as that of another. Another method of getting the desired quality of leather is to blend tanning extracts from different sources. Wattle, in particular, lends itself to this technique. Wattle extract, when mixed with the right kind and quantity of other extracts, may be made to give the desired result.

180. In view of the good prospect for the development of the vegetable tanning industry, countries, well placed with respect to raw material resources, should take steps to supply the growing demand for tanning materials. The development of a few types may satisfy the major part of the demand.

181. As regards chrome tanning agents, the East African 1970 demand was not found to be sufficient to justify an economic unit. This is undoubtedly the case with, at least, Central and West Africa. This industry could be feasible provided it is planned to supply the demand for both the tanning and pigment industry for more than one sub-region. Countries like Rhodesia have most of the material resources for this industry.

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1/ Howes, F.N., Vegetable Tanning Materials, Butterworths Scientific Publications, London, 1953.

182. Sodium silicate and sodium sulphate are from among the remaining chemicals. Sodium silicate which is used in adhesives, detergents, sizing, etc., is being manufactured in some countries, that is, Kenya, Tanzania, Rhodesia and Senegal. It is reported that Morocco has a project for a 5,000 tons per year plant. As the process for sodium silicate is quite simple and as demand for it may be expected to increase, the appearance of more plants in the continent could be envisaged.

183. Sodium sulphate is put to a number of uses of which the Kraft pulp industry is by far the major consumer. Synthetic detergents and glass are among the other consumers. At present this pattern does not apply to Africa. At any rate, although present demand is unknown and possibly small, its future demand could be substantial. It may be possible to satisfy this demand from by-product sodium sulphate from rayon spin baths of the viscose rayon plants that may be established.

## IX. RECOMMENDATIONS

184. The chemical industry is a capital intensive industry characterized by high economies of scale and obsolescence. These characteristics together with the limited size of the market render the development of the chemical industry on a country level impossible for at least many years to come. This unfavourable situation may be improved provided the market is enlarged thereby ensuring the benefits to be derived from economies of scale of relatively larger integrated chemical complexes. Therefore, sub-regional or regional approach is of special significance to the development of the chemical industry in the region. It cannot be over-emphasized that the realization of this approach is a basic prerequisite to the successful development of the chemical industry in Africa.

185. On the assumption that this approach is acceptable, additional recommendations which are of importance for accelerated and successful development of the cehmical industry in the region are put forward:

(a) Investigation of the availability and possible utilization of certain raw materials:

(i) Sulphur and pyrites

(ii) Soda ash (from Lake Chad)

(b) Consideration of alternative processes of production:

(i) Use of gypsum (natural or by-product) for sulphuric acid and ammonium sulphate making,

(ii) Substitution of hydrochloric acid for sulphuric acid in the acidulation of phosphate rock,

(iii) Other processes for maximizing economic disposal of chlorine,

(iv) Causticization of natural soda ash from lakes Magadi and Chad,

(v) Adaption of the Dual Process for soda ash production.

(c) Training and applied research:

(i) Starting immediately preparing and training chemical industry personnel,

(ii) Creation of chemical engineering departments in some universities and polytechnic institutes and strengthening of existing ones,

(iii) Establishment of applied research and development centres combining both research and training.

(d) Miscellaneous:

(i) Adaption of common means of statistical recording and presentation, that is, the Standard International Trade Classification (SITC) for import-export commodities and the International Standard Industrial Classification (ISIC) with details provided by SITC for industrial production,

(ii) Decisive actions on the part of governments to promote use of fertilizers and pesticides,

(iii) Choice of ammonia capacities larger than small turn-key plants,

(iv) Accelerating the development of transportation.